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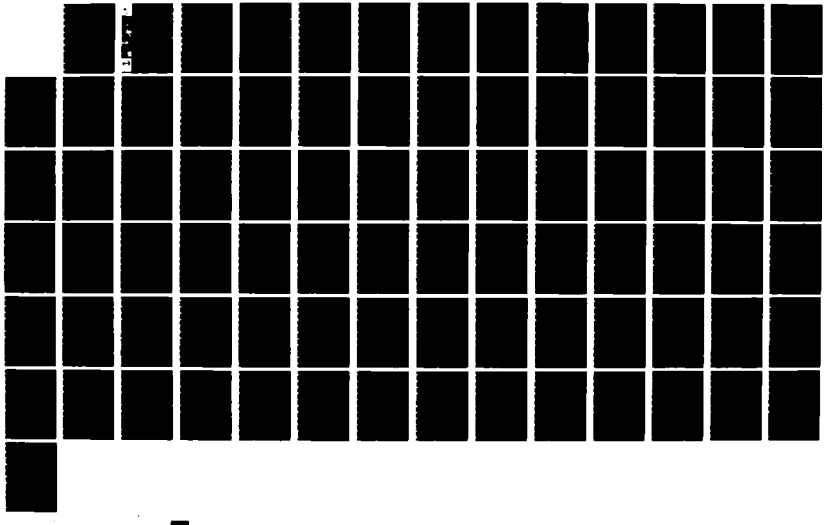

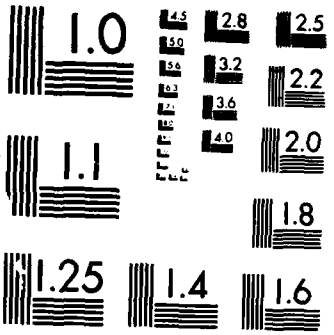

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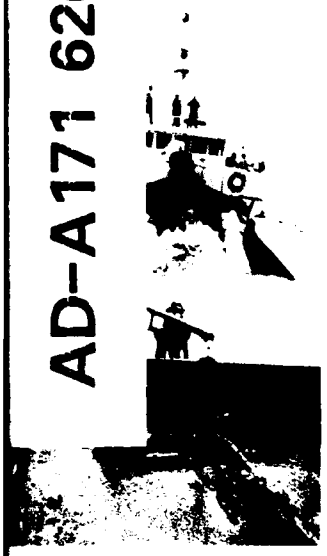
COLONIAL WATERBIRD HABITATS AND NESTING POPULATIONS IN NORTH CAROLINA ESTUARIES: 1983 SURVEY

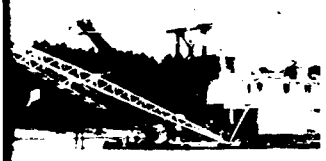
by

James F. Parnell
University of North Carolina at Wilmington
Wilmington, North Carolina

David M. DuMond
Wilmington, North Carolina

Donald A. McCrimmon
Point Reyes Observatory
Stinson Beach, California





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As part of the Dredged Material Research Program, a research project conducted in 1975 demonstrated that colonial waterbirds were using dredged material islands in North Carolina estuaries as nesting sites. At that time, most dredged material islands were not diked. Subsequent research in 1976 and 1977 demonstrated further that most colonial waterbirds nesting in North Carolina were utilizing dredged material islands as nesting sites. Research during that same time period also demonstrated that the practice of diking

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20. Abstract (Continued).

dredged material islands, a practice just coming into regular use in North Carolina, created islands quite different from undiked islands. That study compared community succession and bird utilization on diked and undiked dredged material islands. It showed that diking drastically changed plant succession during the first few years and implied that some species of ground nesting colonial birds such as royal terns may have difficulty in successfully utilizing diked islands as nesting sites.

Most nesting islands in 1977 were, however, still undiked, and most diked islands were only a few years old. Thus, in 1983 nesting colonial waterbirds were censused throughout the North Carolina estuaries to determine whether or not the pattern and degree of use of undiked and diked islands had changed. Vegetation was also sampled on several islands where plant succession had proceeded for an additional 6 or 7 years since the earlier study.

The 1983 research indicated that plant succession on diked islands had continued to occur at an accelerated rate compared with undiked islands. The pattern of succession, as indicated by species present, also continued to differ on the two island types. Undiked islands normally undergo a successional pattern similar to that on barrier islands, while diked sites have greater species diversity and vegetate more quickly. It appears that most seres will differ considerably.

The utilization of diked sites by nesting colonial waterbirds has increased. It appears that, when appropriate habitat is present, most species will nest behind dikes. Royal terns may, however, be an exception, with most colonies remaining on undiked sites. It is also likely that diked sites will be available for shorter periods of time to those species requiring bare or nearly bare substrates. Whether or not reproductive success is different on diked and undiked sites is still not known.

The study also indicated that overall nesting populations of colonial waterbirds have increased since 1977, and populations have dramatically increased on dredged material islands. Laughing gulls, royal terns, brown pelicans, and white ibises showed rather large increases, while gull-billed terns, Forster's terns, least terns, black skimmers, tri-colored herons, snowy egrets, and glossy ibises declined. Increases in bird populations from 1977 to 1983 were 33 percent on undiked and 82 percent on diked islands for ground nesting species, and 16 percent on undiked and 82 percent on diked islands for tree nesting species. A total of 77 percent of all colonial nesting species were nesting on dredged material; 139 colonies (60 percent) were on dredged material islands.

The number of nesting sites being utilized declined, and colony size generally increased. A total of 87 island sites were utilized in 1983, compared with 97 island sites in 1977, a 10-percent decline. These are disturbing signs since they indicate that fewer suitable sites may be available to colonial waterbirds in North Carolina estuaries.

Preface

The study described herein was conducted under Contract No. DACW54-83-M-2877 between the US Army Corps of Engineers and the University of North Carolina at Wilmington, Wilmington, N. C. It was jointly funded by the US Army Engineer Waterways Experiment Station (WES) and the US Army Engineer District, Wilmington.

This study was conducted as part of the Dredging Operations Technical Support Program (DOTS). The DOTS Program is sponsored by the Dredging Division of the Water Resources Support Center, Fort Belvoir, Va., and managed by the Environmental Effects of Dredging Programs (EEDP) in the WES Environmental Laboratory (EL).

The study was conducted and the report written by Dr. James F. Parnell, Department of Biological Sciences, University of North Carolina at Wilmington, Wilmington, N. C.; Mr. David M. DuMond, 225 Cheyanne Trail, Wilmington, N. C.; and Dr. Donald A. McCrimmon, Director, Point Reyes Observatory, Stinson Beach, Calif. Mr. Bill Adams, Wilmington District, and Dr. Mary Landin, WES, were contract managers.

Dr. Robert M. Engler, was Manager, EEDP; Mr. Thomas R. Patin was the DOTS Coordinator. Dr. Conrad J. Kirby was Chief, Environmental Resources Division, EL; and Dr. John Harrison was Chief, EL. This report was edited by Ms. Jamie W. Leach, WES Publications and Graphic Arts Division.

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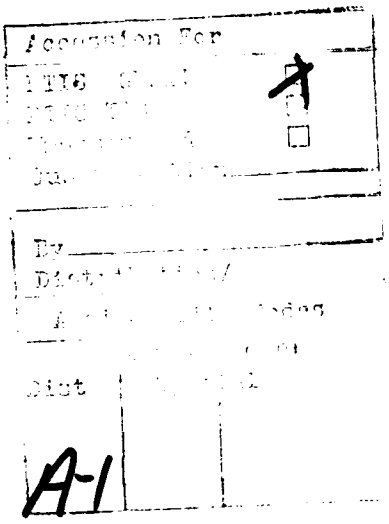

COLONIAL WATERBIRD HABITATS AND NESTING POPULATIONS IN NORTH CAROLINA ESTUARIES: 1983 SURVEY

Introduction

Background

1. During 1976 and 1977, a program of research designed to compare plant succession and bird utilization of diked and undiked dredged material islands in North Carolina estuaries was conducted (Parnell, DuMond, and Needham 1978). This work was a part of the extensive research program directed by the US Army Engineer Waterways Experiment Station (WES) known as the Dredged Material Research Program (Soots and Landin 1978).

2. The work in 1976 and 1977 provided an initial comparison of plant succession in North Carolina on diked and undiked dredged material islands. At that time, however, the extensive use of the process of diking dredged material deposits was just gettin$_{o}$ under way in North Carolina. Most disposal sites were still undiked and the oldest diked sites were about 6 years old. Since 1976 most dredged material deposition in North Carolina has been behind dikes, and the proportion of diked islands has increased.

3. The 1976-77 research showed that diked islands undergo quite different patterns of plant succession and proceeded in this process at different rates from undiked islands. However, at that time the oldest diked islands studied were only 6 years old, so it was not possible to trace the process of succession very far. Some of the pioneer communities on diked islands were quite different from those described by Soots and Parnell (1975) for undiked islands in North Carolina. The process clearly was changing the nature of dredged material islands in North Carolina, but the long-range implications were not clear (Parnell, DuMond, and Needham 1978).

4. The earlier research study also made several comparisons between the use of diked and undiked sites by nesting colonial waterbirds. First, it reemphasized the earlier findings of Soots and Parnell (1975) that dredged material islands were critically important as nesting sites for colonial waterbirds. Second, it found that, while many species of birds nested on diked islands, conclusions about the effect of diking were difficult to

clearly determine. There were, however, indications that diked sites were not as suitable for nesting sites for several species as were undiked sites.

5. The continued research in 1976 and 1977 (Parnell, DuMond, and Needham 1978) led to several recommendations. Further research was recommended over a longer period so that the process of community succession on diked sites over a longer period of time could be seen. It was also recommended that further evaluation of the use of diked islands as nesting sites for colonial waterbirds be made to better understand whether or not the preliminary concerns were real or a factor of the short period of time available for observing colonies on diked sites.

Purpose

6. The current project was thus designed to gather new data on plant succession on diked islands and to compare the use of diked and undiked islands by colonial waterbirds in 1983 with data gathered during the study in 1976 and 1977. A new data set gathered 6 years after the initial study was expected to help clarify the patterns of community succession and the level of acceptance of diked islands by colonial waterbirds.

The Study Area

7. The generalized project area has remained much the same as in the previous study (Parnell, DuMond, and Needham 1978). Dredged material islands throughout the North Carolina estuaries were surveyed for utilization by breeding colonial waterbirds. A portion of the southeastern coastal zone was chosen as the site for plant sampling.

8. Selection of islands for plant sampling was governed largely by the intensity of the maintenance dredging program since the last study. Many islands previously sampled in 1976 and 1977 had been affected by additional dredged material placement and/or by erosion. Since there was a need for previous and present data to be reasonably parallel, such affected islands could not be resampled. This limitation, along with limitations in scope of the present study, redefined the project area for vegetation sampling as a reach of the Atlantic Intracoastal Waterway (AIWW) between Emerald Isle and the lower Cape Fear River near Southport.

9. The character of the generalized biophysical setting of the study area has not changed much since the completion of the earlier study. Minor

changes which have necessitated changes in scope or which may have resulted in localized modification of communities will be discussed in the following paragraphs.

10. The most important changes which have taken place within the study area deal with continued use of diked dredged material islands. Since one of the main efforts of the present study was to follow changes in plant succession on these islands, it was necessary to select islands which had not received new dredged material in the intervening years. During this process of selection, it became quite clear that two age categories of islands were developing: those islands that were constructed long ago and which had received no subsequent dredged material, and those which received regular and frequent deposition. This meant that there were many old islands and many young islands in terms of vegetative communities present. There were few islands with intermediate age plant communities.

Methods

11. Methodology employed during the course of this study was similar to that used in the 1976-77 study (Parnell, DuMond, and Needham 1978). Methods of vegetation sampling and transect terminology were exactly the same, due to the need for parallel data. Some variations were necessary in the sampling of bird data due to smaller field crews and a more restricted time frame for field work. Sampling of island soils was not within the scope of this project as it was for the 1976-77 study.

Vegetation sampling and analysis

12. Transects for vegetation sampling were established on islands which had received no additional deposits of dredged material since the previous study and on which sampling had previously taken place. Transects were established within 10 m to one side or the other of the previously established transects and sampling proceeded along the 0.5-m width of the transect at alternate 1-m intervals. Sampling on dikes and drift ridges, as in the previous study, was conducted at each interval.

Bird sampling and analysis

13. The primary goal of the bird surveys was to compare the use of diked and undiked islands by colonial waterbirds in 1983 with data gathered in 1977. All nesting sites occupied by colonial waterbirds in the North Carolina

estuaries were located using a Cessna 172 fixed wing aircraft on 16 and 17 May 1983. Each colony was visited between 16 May and 17 June 1985. At each colony information was gathered on both the site and bird colonies present. A colony was defined as four or more nests of one of the species being studied, and several colonies could have been present at any given site. Data sheets used were identical to those used in 1977.

14. Each site was visited two or more times in 1977 and a summation of population data was used to arrive at total counts for each colony. This process was time-consuming and expensive, so in this survey each site was visited only once in 1983. This visit was scheduled to coincide as closely as possible with the peak of the incubation period, assuming that most birds would be present at this time. This could have led to an underestimate of total breeding populations, as late nesters were not counted. However, the weather was warm and dry in 1983 and most birds began the nesting cycle at about the same time.

15. It was necessary to reevaluate some of the 1977 data to allow valid comparisons with the new data set. Peak nesting populations for 1977 were recalculated, using only data from the first visit. This allowed direct comparisons between 1977 and 1983 data sets, but meant that the 1977 data presented in this report differ from those in Parnell, DuMond, and Needham (1978). Actual censuses were conducted using the same techniques described in Parnell, DuMond, and Needham (1978), with the exception of total nest counts in 1983. In the largest of the laughing gull colonies, sample strip censuses were used, and in one royal tern colony a partial count was used to generate a total estimate.

16. Figures 1-26 were adapted directly from those used in the 1978 report (Parnell, DuMond, and Needham 1978). They were modified to reflect the loss of some of the dredged material islands from the study and the creation of other islands. All sites which contained bird colonies in 1977 or 1983 are located on these maps. Sites used for the studies of island vegetation are also located on the maps. Table 1 provides a list of all colony sites keyed by number to the map figures. Each site was given a double number according to the scheme utilized by Parnell and Soots (1979).

Results and Discussion

Vegetation

17. Since the objective of the vegetation sampling portion of the present project was to continue monitoring changes in species presence and cover, the same transects sampled in 1976 and/or 1977 were resurveyed on seven islands. A period of 6 or 7 years, respectively, has elapsed since the initial sampling, and changes in the character of vegetative cover were to be expected.

18. During the previous study, it was recognized that along any transect, there may be dredged material deposit surfaces of different ages. For example, dikes may have been constructed on undiked dredged material islands, but never used to contain new dredged material. In effect, this modification of an island created two new surfaces, the borrow area and the dike. It influenced a third, the outer swale, by redeposition of materials eroded from the new dike. Several deposition activities were also found to truncate surfaces of similar ages on diked islands. It became necessary to develop a chronology of topographic surfaces, and to use care in defining their boundaries during field sampling.

19. The age of surfaces sampled during the present study was accounted for during field sampling (Table 2). Due to the small size of the sample during the present study, vegetation importance values were not calculated for all surfaces of similar ages. Instead, values were computed for entire transects (Tables 3-16).

20. A change in importance of plant species in an area through time was one of the expected results of natural succession. Changes could be implied by shifts in dominance and gains or losses of species within a sample area. As far as the present study is concerned, such changes could not be accurately inferred from the data alone (Tables 3-16). This deficiency in the data occurred for two reasons: (a) small permanent plots allowing repeated sampling of an area without disturbance to the vegetation were not originally established, and (b) sampling times were not completely seasonally equivalent. The following discussion will attempt to clarify the data through the use of qualitative observations made during the course of the sampling.

21. Some profound changes had occurred along Transect 1, Island 39-28, since the 1976 sampling (Table 3). Common reed (*Phragmites australis*) had

spread into a nearly monospecific stand, continuous from the outside slopes of the dikes across the inner flat of the disposal area. Crabgrass (*Cynodon dactylon*), once dominant on the dike, had been replaced by common reed, as had aster (*Aster subulatus*) and other species in the inner flat. Erosion of the outer swale (Table 2) had nearly eliminated previous dominance by smooth cordgrass (*Spartina alterniflora*) along the transect. The organic soil of the inner flat had been invaded by at least two species which could ultimately gain co-dominance if the soils remain moist enough. These species which had appeared since 1976 were sawgrass (*Cladium jamaicense*) and redbay (*Persea borbonia*). The shift in importance of pokeweed (*Phytolacca americana*) probably took place before closure of the common reed canopy. The condition of the pokeweed along the inner flat indicated that it was being stressed by increased shading. Silverling (*Baccharis halimifolia*) had also increased in importance, and is likely to continue to do so since it can compete effectively in shade.

22. Island 37-12 was an undiked deposit of sandy dredged material 13 years old (Table 2). Sampling of vegetation along transects established on this island began during the first year of its existence (Soots and Parnell 1975). Repeated sampling was accomplished in 1977 and 1983 (Table 4). Implied gains and losses shown in the data in Table 4 are real. Drift ridges invaded by wax myrtle (*Myrica cerifera*) were nearly dominated by this species. Though minor shifts in importance can most likely be attributed to sampling error, succession along the slopes and domes of the undiked deposit was generally proceeding in the manner established in earlier studies (Soots and Parnell 1975; Parnell, DuMond, and Needham 1978).

23. Major successional changes cannot be inferred from the data in Transect 1 on Island 36-14 (Table 5). Apparent shifts in dominance for most species except saltmeadow cordgrass (*Spartina patens*) can probably be attributed to sampling error, although the gains and losses of species are generally true. The data from the second transect along Island 36-14 presented much the same picture as those for Transect 1 (Table 6). Significant portions of both transects passed across stable surfaces of old undiked deposits bisected by younger dikes (Table 2). The predominant portion of the change had occurred on dikes and borrow pits, but demonstration of this change was buffered by a lumping with data from older, less dynamic topographic surfaces.

24. A more classical picture of successional change was presented in comparison of three sets of data for Transect 3 from the above island (Table 7). All topographic surfaces crossed by this sample were of nearly uniform age. The decrease in importance values for saltmeadow cordgrass was a reflection of the relative nature of importance values. The apparent invasion by new species over a span of 7 years was an expected result of succession on new surfaces.

25. The real evidence for successional change in the sample from Transects 1 and 2 on Island 36-13 was again confused by incorporation of data from relatively new surfaces (dike, borrow area, or dozer scrape) with that from a relatively old surface (outer swale) (Tables 2, 8, and 9). The importance values in Transect 1 for wax myrtle largely represented data from an old-growth stand dominated by the same species. Several species seemed to have invaded the sample area during the intervening years, while others seemed to have disappeared. The net degree of change implied by the data and observed in the field remained minimal. Newer surfaces showed the most change as a result of invasion of new species.

26. Transect 3 on the above island presented a different result of succession (Table 10). In 1976, morning glory (*Ipomoea sagittata*) and pennywort (*Hydrocotyle verticillata*) did not appear in the sample, but in 1983 they had become dominant. The loss of yucca (*Yucca filamentosa*) was unusual, but may simply have represented a shift in the alignment of the transect. Once yucca is established, it tends to remain unless shaded out. The loss of frogfruit (*Lippia nodiflora*) was likely due to the increase in abundance of the more competitive morning glory.

27. The data for Island 28-01 implied a profound change that was also observed in the field (Table 11). The shift in co-dominance from aster and silverling in 1976 to silverling and poison ivy (*Toxicodendron radicans*) in 1983 was obvious. Even by 1977, the population of aster had failed to reestablish as it had in the moist organic dredged material in 1976. Silverling had become dominant. A portion of the low importance value of aster in 1977 was due to a seasonal inconsistency in sampling. Nonetheless, it had become less dense and was completely replaced by 1983. Loss of some species between 1977 and 1983 was due to erosion of the outer swale (Table 2). Other species succumbed to the superior competitive nature of silverling and poison

ivy in this type of habitat. This diked island presented an excellent example of plant succession over a short period of time.

28. Saltmeadow cordgrass was the most abundant single species on sandy dredged material islands of intermediate age (2 to 9 years). With one exception, it was observed to increase in areal extent between 1976 and 1983 on islands 22-25 and 22-26 (Tables 12-16). Because of the increase in importance of other species (*Heterotheca, Erigeron,* and *Triplasis*), saltmeadow cordgrass appeared to decrease in Transect 3, Island 22-25. Both wind and water erosion resulted in a partial rearrangement of surfaces along some transects on these islands (Table 2), adding to the differences between previous and current sample data. Sands from dredged material had been blown into the outer swale of the transect, for instance, covering some of the previously more abundant saltgrass (*Distichlis spicata*), sea oxeye (*Borrichia frutescens*), and black needlerush (*Juncus roemerianus*), and providing increased substrate for the growth of saltmeadow cordgrass (Table 12). Species which typically occupy upper sandy slopes and domes (*Heterotheca, Oenothera, Erigeron,* and *Euphorbia*) became particularly apparent in the 1983 sampling. They invaded the island since 1976, when the deposit within the dike was little more than coarse sand.

29. Portions of Island 22-25 were eroded by storm tides and boat wakes between 1977 and 1983 (Tables 15 and 16). Outer swale communities dominated by salt or brackish marsh species (*Paspalum, Iva, Borrichia, Distichlis,* and *Spartina alterniflora*) were all but removed by shoreline erosion.

30. By removal of fine sands, which were in large part deposited on or near dikes, coarse sand and shell substrate had been exposed along some portions of Island 22-25. Coarse substrates were less suitable, even if level, for growth of species previously mentioned as characteristic for upper slopes and domes. The result of erosion and the subsequent loss of cover by these species could be seen clearly in data for Transect 2 (Table 14) and to some extent in the data for Transect 1 (Table 13).

Birds

31. The basic data set for colonial waterbird populations in North Carolina estuaries in 1983 is presented in Table 1. This table shows which islands were occupied and the numbers of nests of each species present, and indicates whether the site was a barrier island, dredged material island, or natural estuarine island. It also indicates whether or not dredged material

sites were diked. All sites with nesting birds are also located on the series of maps comprising Figures 1-26.

32. Tables 17 through 21 provide summaries of population and site selection data from both 1977 and 1983 and are the basis for comparisons between years. Table 17 shows that there was an apparent increase in the number of nests of the ground nesting gulls, terns, and pelicans during the six nesting seasons since 1977. An increase of over 23,000 nests epresented a population increase of about 14 percent annually. However, the gull-billed terns (*Gelochelidon nilotica*), common terns (*Sterna hirundo*), Forster's terns (*Sterna forsteri*), least terns (*Sterna albifrons*), and black skimmers (*Rynchops niger*) actually declined in numbers while dramatic increases in numbers of nesting brown pelicans (*Pelecanus occidentalis*), laughing gulls (*Larus atricilla*), and royal terns (*Sterna maxima*) accounted for most of the increase.

33. Numbers of colonially nesting wading birds also showed an increase of 2,391 nests (Table 18) or about 5 percent per year. Again, however, most of this was accounted for by increases in numbers of little blue herons (*Florida caerulea*), great egrets (*Egretta albus*), cattle egrets (*Bubulcus ibis*), and especially white ibises (*Eudocimus albus*). Several species of waders, most notably snowy egrets (*Egretta thula*) and glossy ibises (*Plegadis falcinellus*) declined. The ground nesting pelicans, gulls, and terns utilized the same kinds of sites in 1983 that they had occupied in 1977. Time constraints in 1983, however, prevented a thorough search for small colonies on the mainland side of Pamlico Sound in northeastern North Carolina, and a few small colonies of least terns may have been missed.

34. Table 19 provides a comparison between sites utilized in 1977 and 1983 for ground nesting waterbirds. Note that there were 25 fewer colonies located in 1983 than in 1977. Colonies on natural estuarine sites declined by 18 while barrier island colonies declined by 6. The decline at other sites was primarily accounted for by the lack of mainland sites located during the 1983 survey. Colonies of gulls and terns on dredged material sites increased in 1983. There were eight more colonies on dredged material islands in 1983 than in 1977. The indication was clearly that the ground nesters were continuing to increase their dependence on dredged material islands. If this comparison were made on the basis of numbers of nests rather than on numbers of colonies, similar conclusions would be reached (Table 17). Colonies on

barrier beaches were smaller in 1983 than in 1977, but colonies on natural estuarine and dredged material islands were considerably larger in 1983 than in 1977.

35. The same general trend appeared to be occurring in wading bird populations. There were 15 fewer colonies in 1983 (Table 20) but there was a 34-percent increase in the population (Table 18). Numbers of colonies at most site types was about the same in 1983 as in 1977, except that the numbers of colonies on undiked dredged material sites declined by 17 (Table 20). Colony size on all site habitat types increased, however, with the most dramatic increase being the increase in numbers of nests on diked sites (Table 18). Notice that actual numbers of nests on diked sites were still much lower than on undiked dredged material islands. About two thirds of all wading birds nested in 1983 on undiked dredged material islands.

36. If the data were combined for all colonial waterbirds, several conclusions can be drawn (Table 21). First, it appears that total populations had increased during the period between 1977 and 1983. There is a potential source of error in the comparisons. If the birds nested earlier in 1983 than in 1977, the peak count in 1983 could represent a greater portion of the total nesting population. This would result in an overestimate of population growth between 1977 and 1983. While the peak count method should allow valid comparisons, it would be necessary to repeat the censuses for another year or two to become confident of the validity of the comparisons. There had obviously been an increase in numbers of nests, but the significance of the amount of the increase is difficult to determine. It does appear that numbers of colonies and number of sites used declined between 1977 and 1978. There were 10 fewer sites in 1983 and 31 fewer colonies of birds (Table 21). This means that there were fewer larger colonies of nesting birds occupying fewer sites in the North Carolina estuaries. While the increase in numbers of nesting birds was a positive sign, the decline in sites used may indicate future problems. Most biologists feel that more, smaller colonies at many sites provides better protection from catastrophe, disease, and disturbance (Soots and Landin 1978). This trend should be monitored closely.

37. It is clear from these data that the dredged material islands continued to be very important nesting sites for these bird species. In 1983, 78 percent of all colonial waterbirds (both seabirds and wading birds) nested on dredged material island sites compared with 66 percent during the peak

period in 1977. Numbers on natural estuarine islands also increased but at a lower level. Numbers of birds nesting on the barrier islands remained about the same in spite of the increase in the nesting population (Table 21).

38. The primary purpose of this study was to evaluate the use of undiked and diked dredged material islands and to make comparisons between 1977 and 1983. Table 21 shows that the number of colonies on undiked islands actually declined by 12 percent while the number of colonies on diked islands increased by 22 percent. The numbers of nests on both site types increased dramatically, and were up 51 percent on undiked sites and 455 percent on diked sites. Undiked islands still had almost twice the actual number of nests as diked sites, but at the present rate the difference may soon be eliminated.

39. Much of the change can be explained by looking in Table 17 at the two most abundant species--the royal tern and the laughing gull. Both species had increased greatly since 1977. Laughing gulls had also increased their use of diked islands, but most royal terns continued to nest on undiked sites. Royal terns preferred bare sandy island domes, conditions most often found on undiked islands.

40. Other species such as gull-billed terns, common terns, least terns, and black skimmers also appeared to be occurring more often on diked sites in 1983 than in 1977 (Table 19). These species are pioneer site nesters, and often nest on recently disturbed sites for a year or two before moving on. They will, for example, nest in the scraped areas that bulldozers or drag lines create when building or repairing dikes.

41. It thus appears that most species of ground nesting colonial waterbirds nesting in the North Carolina estuaries will utilize diked sites if appropriate habitat is present behind the dikes. Royal terns still appear to nest primarily on undiked sites but most of the other ground nesting species are increasing their use of diked sites. Most wading bird colonies are still on undiked sites. In one site, Island 14-04, a thicket has developed since the island was diked and a small heronry has become established. Thus, wading birds appear to be attracted by appropriate vegetation type and may not be affected by the presence of a dike.

Conclusions and Recommendations

42. The vegetation data previously discussed seem to have two failings

related to a lack of seasonal congruency and to sample area equivalency. Despite these sample errors, the data do represent real changes in both species composition and areal extent of vegetation cover when compared with qualitative field observations.

43. Surfaces sampled in 1976 or 1977 had in some cases been eroded by wind or water, making interpretation of the plant successional data meaningless. Erosion was an expected manifestation of the physical environment of North Carolina estuaries, however, and truncation of adjacent habitats by wind and water was not unusual.

44. Sampling of undiked islands was very limited, but trends seem predictable as indicated by the data. Differences between vegetation types of similar seres on diked deposits were frequently greater than between those on undiked deposits. A wider variety of substrate types were enclosed by dikes. Although diking was relatively recent and development of vegetation had not as yet passed beyond very early seres on diked islands, there was evidence to support the idea that older seres on diked islands would differ greatly from older seres on undiked islands. Differences between many early seres were also very great.

45. Newer surfaces available for plant invasion, as a general rule, changed at a more rapid rate than did older surfaces. This profoundly confused the successional patterns on diked islands in the study area. Due to the practice of diking older undiked deposits and later placing new dredged material within the dikes, the different topographic surfaces along any transect could vary considerably in age and successional development. A dense cover of grasses and forbs often developed within 1 or 2 years along dikes constructed of older dredged material while the deposit, if domed and sloped within the containment, could remain bare or only sparsely vegetated for several years.

46. The dredging needs in North Carolina estuaries cannot be anticipated, but it appears that a trend exists in island disposal area creation and maintenance. Few or no new islands are being created, and many undiked islands have been converted to diked islands. Several undiked islands remain and some may be as old as the original construction of the AIWW. These older islands were dominated by arborescent vegetation and a few are eroding. Almost all freshly deposited dredged material was behind dikes during this study, making the resulting seral stages of plant succession vastly different

from those on natural barrier beaches and dunes. Seral stages on undiked islands that received irregular deposits of new material were very similar to natural seres along barrier beaches and dunes.

47. It is still too soon to make a final evaluation of the effect of dikes on nesting colonial waterbirds. Plant studies continue to show rapid development of vegetation on diked sites as compared with undiked sites. Diked sites will provide the pioneer species with appropriate habitat for shorter periods of time than will undiked islands. Seral stages are also changing. Species preferring the more heavily vegetated sites may be benefited, but these are the kind of sites that are usually in good supply. Those especially important undiked islands which regularly are occupied by several large colonies of nesting birds should not be diked. In addition, management to maintain these sites in early stages of plant succession should be encouraged.

48. Whether or not there were differences in reproductive success on diked and undiked sites is not known. In the 1976-1977 project (Parnell, DuMond, and Needham 1978) it was suspected that birds nesting behind dikes were subject to additional pressures such as flooding after heavy rains. The current project did not add any new insight into this problem, and studies evaluating reproductive success on diked and undiked sites are needed. Surveys such as that accomplished in 1983, conducted at about 5-year intervals, should also be continued to allow further evaluation of trends in nesting numbers and nesting habitat associations of these important components of coastal ecosystems. It is not yet clear how colonial waterbird populations will react to changes in estuarine ecosystems associated with recent changes in the dredging process. The general outlook in North Carolina is good for most species, but there are indications of future problems if suitable nesting sites continue to decrease in numbers. This is likely to become especially critical for pioneer species such as royal and Sandwich terns that nest on bare or nearly bare sandy sites.

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Table 1

Colonial Waterbird Colony Locations, Site Conditions, and Numbers of Nests in North Carolina Estuaries in 1983

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
01-01	36°21'	75°52'	natural, estuarine	great egret	148
				tri-colored heron	08
				snowy egret	18
				cattle egret	420
				little blue heron	95
				green-backed heron	01
03-02	35°50'	75°36'	dredged	herring gull	06
03-04	35°50'	75°36'	dredged, diked	herring gull	12
				gull-billed tern	29
				common tern	38
				least tern	94
				black skimmer	13
03-07	35°48'	75°35'	dredged	herring gull	22
03-09	35°49'	75°35'	dredged	great egret	79
				tri-colored heron	137
				snowy egret	47
				cattle egret	51
				little blue heron	145
				black-crowned night heron	35
				white ibis	01
				glossy ibis	81
				herring gull	155
				laughing gull	591
05-06	35°46'	75°31'	dredged	Caspian tern	04
				black skimmer	65
06-02	35°46'	75°35'	dredged	herring gull	04
				laughing gull	1029
				royal tern	5000
				Sandwich tern	150
06-08	35°46'	75°35'	dredged	brown pelican	03
				herring gull	94
				Caspian tern	02

(Continued)

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
06-09	35°42'	75°46'	dredged	gull-billed tern	15
				common tern	129
				black skimmer	19
06-10	35°12'	75°36'	dredged	great egret	07
				tri-colored heron	02
				snowy egret	07
				cattle egret	04
				little blue heron	14
				herring gull	09
				Forster's tern	91
				common tern	111
				royal tern	1,337
				Sandwich tern	362
06-12	35°28'	75°31'	natural, estuarine	great egret	03
				tri-colored heron	01
				snowy egret	02
				black-crowned night heron	03
				herring gull	06
				laughing gull	3,546
				Forster's tern	57
06-14	35°20'	76°22'	natural, estuarine	Forster's tern	68
				common tern	142
06-20	34°59'	76°23'	natural, estuarine	herring gull	02
				laughing gull	35
				common tern	04
				black skimmer	04
06-30	35°22'	76°04'	natural, estuarine	Forster's tern	308
07-04	35°43'	75°30'	man-made within impound-ment	great egret	37
				tri-colored heron	91
				snowy egret	111
				cattle egret	01
				little blue heron	58
				black-crowned night heron	27
				white ibis	01
				glossy ibis	20
				yellow-crowned night heron	07

(Continued)

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
07-05	35°42'	75°30'	man-made within impound-ment	common tern black skimmer	31* 12*
07-06	35°43'	75°30'	man-made within impound-ment	common tern	04
08-0101	35°37'	75°28'	barrier island	least tern black skimmer	24 03
08-0106	35°31'	75°28'	barrier island	least tern	53
08-0107	35°27'	75°30'	barrier island	gull-billed tern common tern least tern black skimmer	04 81 44 03
08-02	35°13'	75°41'	barrier island	common tern least tern	07 251
09-01	35°12'	76°16'	barrier island	gull-billed tern common tern least tern black skimmer	03 39 128 82
09-02	35°11'	75°47'	barrier island	common tern black skimmer	75 02
09-03	35°13'	75°45'	dredged	laughing gull gull-billed tern Forster's tern common tern royal tern Sandwich tern black skimmer	2,685 07 116 84 2,021 238 40
10-02	35°11'	75°48'	natural, estuarine	glossy ibis herring gull laughing gull Forster's tern	15 02 08 36

(Continued)

* Estimate based on adult count only.

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
10-14	35°09'	75°52'	barrier island	great egret	07*
				black-crowned night heron	19*
10-15	35°09'	75°51'	barrier island	great egret	21
11-01	35°04'	76°00'	barrier island	Forster's tern	63
				common tern	526
				least tern	08
				black skimmer	194
11-04	35°06'	76°03'	natural, estuarine	brown pelican	751
				herring gull	68
				laughing gull	3,087
				Forster's tern	86
11-05	35°06'	76°03'	man altered	herring gull	15
11-06	35°06'	76°04'	man altered	herring gull	36
11-07	35°07'	76°04'	man altered	great egret	02
				tri-colored heron	104
				snowy egret	61
				little blue heron	72
				black-crowned night heron	06
				glossy ibis	03
				herring gull	02
				common tern	13
12-01	35°01'	76°07'	barrier island	common tern	02
				least tern	06
12-14	35°00'	76°09'	natural, estuarine	Forster's tern	31
12-23	35°05'	76°04'	natural, estuarine	Forster's tern	16
12-24	35°04'	76°06'	natural, estuarine	herring gull	17
				royal tern	422

(Continued)

* Estimate based on adult count only.

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
13-01	35°58'	76°10'	natural, estuarine	Forster's tern	40
14-01	34°59'	76°12'	natural, estuarine	laughing gull	04
				Forster's tern	03
				common tern	02
14-02	34°59'	76°12'	dredged	great egret	19
				tri-colored heron	05
				snowy egret	11
				little blue heron	06
				black-crowned night heron	05
14-03	34°59'	76°13'	natural, estuarine	herring gull	01
				common tern	02
14-04	34°52'	76°20'	dredged, diked	great egret	01
				tri-colored heron	15
				snowy egret	01
				brown pelican	02
				laughing gull	9,796
				royal tern	3,072
				Sandwich tern	958
14-13	34°45'	76°26'	barrier island	least tern	01
14-17	34°53'	76°17'	barrier island	gull-billed tern	03
				common tern	12
				least tern	120
				black skimmer	08
14-22	34°37'	76°32'	barrier island	least tern	07
14-24	34°36'	76°33'	barrier island	least tern	132
14-25	34°39'	76°30'	barrier island	least tern	04
16-01	34°54'	76°17'	dredged	common tern	44
				black skimmer	29
16-04	34°54'	76°15'	natural, estuarine	Forster's tern	15

(Continued)

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
17-01	34°40'	76°32'	dredged, diked	great egret	02
				tri-colored heron	12
				snowy egret	08
				little blue heron	03
				black-crowned night heron	03
				laughing gull	64
				gull-billed tern	06
				common tern	08
				black skimmer	14
17-03	34°39'	76°32'	dredged	laughing gull	402
17-07	34°40'	76°31'	dredged	laughing gull	191
				gull-billed tern	05
				common tern	74
				royal tern	1,555
				Sandwich tern	95
				black skimmer	84
17-08	34°40'	76°31'	dredged	laughing gull	23
18-08	34°41'	76°35'	natural, estuarine	common tern	73
18-11	34°40'	76°32'	natural, estuarine	Forster's tern	02
				common tern	10
18-12	34°40'	76°34'	natural, estuarine	Forster's tern	04
				common tern	03
18-15	34°42'	76°37'	natural, estuarine	great egret	38
				tri-colored heron	118
				snowy egret	48
				little blue heron	33
				black-crowned night heron	11
				glossy ibis	04
18-20	34°39'	76°32'	natural, estuarine	common tern	14
20-06	34°42'	76°42'	dredged, diked	gull-billed tern	64
				common tern	576
				least tern	58
				black skimmer	157

(Continued)

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
21-01	34°44'	76°42'	dredged, diked	least tern	24
21-03	34°44'	76°42'	dredged, diked	great egret	11
				tri-colored heron	141
				snowy egret	39
				cattle egret	518
				little blue heron	269
				black-crowned night heron	80
				white ibis	85
				yellow-crowned night heron	02
21-04	34°44'	76°41'	dredged	great egret	142
				tri-colored heron	25
				cattle egret	15
				green-backed heron	01
				black-crowned night heron	10
				white ibis	01
22-39	34°41'	77°01'	dredged, diked	common tern	01
				least tern	37
22-41	34°40'	77°02'	dredged	great egret	68
				tri-colored heron	08
				little blue heron	08
				green-backed heron	01
22-42	34°40'	77°03'	dredged	great egret	21
				tri-colored heron	327
				snowy egret	30
				cattle egret	133
				little blue heron	265
				green-backed heron	04
				black-crowned night heron	09
22-44	34°40'	77°05'	dredged, diked	least tern	10
22-45	34°40'	77°06'	dredged, diked	least tern	92
26-06	34°33'	77°21'	dredged, diked	least tern	55

(Continued)

Table 1 (Continued)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
26-07	34°43'	77°21'	dredged, diked	green-backed heron	15
				common tern	02
				least tern	96
29-43	34°19'	77°43'	dredged, diked	least tern	05
30-01	34°21'	77°39'	barrier island	least tern	49
30-02	34°21'	77°39'	barrier island	least tern	07
32-01	34°18'	77°43'	barrier island	common tern	96
				least tern	92
				black skimmer	38
32-02	34°18'	77°43'	barrier island	least tern	07
33-16	34°15'	77°47'	dredged, diked	least tern	16
35-02	34°11'	77°49'	barrier island	common tern	36
				least tern	32
				black skimmer	39
36-03	34°12'	77°49'	dredged, diked	least tern	07
37-18	34°05'	77°53'	dredged	least tern	25
39-25	34°03'	77°56'	dredged, diked	gull-billed tern	41
				least tern	27
39-30	34°00'	77°57'	dredged	laughing gull	247
39-32	33°59'	77°57'	dredged	brown pelican	355
				laughing gull	531
				royal tern	1,651
				Sandwich tern	18
39-33	33°58'	77°57'	dredged, diked	black skimmer	03

(Continued)

Table 1 (Concluded)

Island Number	Coordinates Latitude	Coordinates Longitude	Site Condition	Species Present	Total Nests
39-36	33°56'	77°51'	dredged	gull-billed tern	52
39-37	33°56'	77°51'	dredged	brown pelican	222
				laughing gull	664
				royal tern	1,971
				Sandwich tern	29
39-46	33°54'	78°01'	natural, estuarine; receiving dredged material	great egret	42
				tri-colored heron	239
				snowy egret	100
				little blue heron	196
				green-backed heron	02
				black-crowned night heron	27
				white ibis	3,737
				glossy ibis	31
39-49	33° 54'	77° 56'	barrier island	least tern	80
39-51	33° 54'	78° 01'	natural, estuarine; receiving dredged material	great egret	191
				tri-colored heron	166
				snowy egret	232
				cattle egret	306
				black-crowned night heron	34
				glossy ibis	137
43-09	33° 55'	78° 23'	dredged, diked	least tern	42

Table 2

Summary of Ages and Conditions of Transects Sampled in 1976, 1977, and 1983

Island Number	Transect Number	Topography Type	Age 1976	1977	1983
39-28	1	outer swale	2	--	9*
		outside slope	2	--	9
		ridge	2	--	9
		inside slope	2	--	9
		central flat	2	--	9
37-12 (undiked)	1	entire transect	--	7	13
36-14	1	dike	1	--	8
		borrow	1	--	8
		dome	10+	--	17+
	2	outer swale	mix of old undiked lower drift, lower and upper drift ridge, probably 10+, but impacted 1, 2, and 8 years ago		
	3	entire transect	1	2	8
36-13	1	outer swale	mix of lower drift and lower slope of undiked deposit, probably 10+, 11+, 17+ years ago		
		dike	4	5	11
		borrow pit	4	5	11
		disturbed ecotone	4	5	11
	2	outer swale	upper slope of old undiked deposit, probably 10+, 11+, 17+ years old		
		dike	4	5	11
		dozer scrape	4	5	11
	3	all zones	1	--	8
28-01	1	entire transect	5	6	12*
22-26	1		2	3	9**
22-25	All		2	3	9
	3*	outer swale*			
	4**	outer swale*			

* Modified by water erosion.

** Modified by wind erosion.

Table 3

Importance Values of Plant Species Occurring Along

Transect 1, Island 39-28

Species	1976	1983
Phragmites australis	69	126
Cynodon dactylon	43	--
Aster subulatus	35	--
Spartina alterniflora	13	6
Lactuca canadensis	9	--
Digitaria spp.	7	--
Eupatorium capillifolium	6	--
Lactuca spp.	4	--
Eleusine indica	3	--
Polygonum lapathifolium	3	--
Chenopodium ambrosioides	2	2
Elymus virginicus	2	--
Oenothera humifusa	1	--
Phytolacca americana	1	24
Baccharis halimifolia	1	--
Cladium jamaicense	--	15
Paspalum urvillei	--	8
Persea borbonia	--	4
Alternanthera philoxeroides	--	2
Aster tenuifolius	--	2
Erechtitis heiracifolia	--	2
Erigeron canadensis	--	2
Rubus flagellaris	--	2
Galium tinctorum	--	2

Table 4

Importance Values of Plant Species Occurring Along Transect 1, Island 37-12

Species	1977	1983
Solidago sempervirens	26	14
Ptilimnium capillaceum	20	--
Phragmites australis	19	13
Spartina patens	18	20
Strophostyles helvola	13	8
Triplasis purpurea	12	14
Panicum virgatum	11	4
Oenothera humifusa	8	13
Agalinis fasiculata	7	8
Scirpus americanus	6	5
Heterotheca subaxillaris	6	8
Iva imbricata	5	--
Cenchrus tribuloides	5	--
Andropogon virginicus	4	5
Fimbristylis castanea	4	3
Lactuca canadensis	4	2
Gnaphalium purpureum	4	--
Eupatorium capillifolium	4	--
Borrichia frutescens	4	7
Erigeron canadensis	3	12
Euphorbia polygonifolia	3	2
Unidentified grass	2	--
Commelina communis	2	3
Toxicodendron radicans	1	1
Aster pilosus	1	--
Baccharis halimifolia	1	4
Uniola paniculata	1	3
Parthenocissus quinquefolia	0*	2
Ampelopsis arborea	0	0
Chloris petrea	0	--
Pinus taeda	0	--
Sabatia stellaris	0	--
Ipomoea sagittata	0	0

(Continued)

* An entry of 0 indicates the importance value was less than 1.

Table 4 (Concluded)

Species	1977	1983
Solidago altissima	0	--
Erigeron spp.	0	--
Myrica cerifera	--	15
Hydrocolyte verticilatta	--	12
Limonium carolinianum	--	5
Spartina alterniflora	--	3
Distichlis spicata	--	3
Baccharis angustifolia	1	2
Acer rubrum	--	2
Aster tenuifolius	--	2
Salicornia virginica	--	2
Pyrrhopappus carolinianus	--	1
Lactuca spp.	--	1
Unidentified herb	--	0
Prunus serotina	--	0
Elymus virginicus	--	0
Solidago altissima	--	0
Gnaphalium purpureum	--	0

Table 5

Importance Values of Plant Species Occurring Along Transect 1, Island 36-14

Species	1976	1983
Spartina alterniflora	34	18
Spartina patens	25	61
Erigeron canadensis	23	4
Heterotheca subaxillaris	17	11
Distichlis spicata	16	7
Limonium carolinianum	16	9
Aster tenuifolius	11	17
Solidago sempervirens	10	5
Commelina communis	9	9
Fimbristylis castanea	9	15
Cynanchum palustre	8	--
Physalis viscosa	5	2
Panicum virgatum	4	6
Oenothera humifusa	3	5
Borrichia frutescens	3	9
Chloris petrea	2	--
Andropogon virginicus	2	1
Yucca filamentosa	2	5
Ipomoea sagittata	2	--
Strophostyles helvola	--	5
Juncus roemerianus	--	5
Myrica cerifera	--	5
Agalinis maritima	--	2

Table 6

Importance Values of Plant Species Occurring

Along Transect 2, Island 36-14

Species	1976	1977	1983
Spartina patens	29	31	34
Oenothera humifusa	16	3	18
Heterotheca subaxillaris	13	11	5
Baccharis angustifolia	12	5	--
Physalis viscosa	11	18	11
Andropogon virginicus	11	4	1
Limonium carolinianum	11	14	7
Borrichia frutescens	10	11	4
Fimbrystylis castanea	10	26	5
Iva frutescens	10	1	5
Erigeron canadensis	9	6	18
Chloris petrea	7	3	2
Spartina alterniflora	7	4	3
Agalinis fasiculata	7	--	3
Panicum virgatum	6	11	5
Aster tenuifolius	6	7	5
Solidago sempervirens	5	9	5
Commelina communis	5	5	8
Triplasis purpurea	5	9	14
Myrica cerifera	3	--	--
Agalinis purpurea	1	2	--
Galium hispidulum	1	1	--
Poa spp.	1	--	--
Distichlis spicata	1	3	2
Sabatia stellaris	1	1	--
Euphorbia polygonifolia	1	12	6
Gnaphalium purpurem	1	--	--
Eupatorium capillifolium	1	--	--
Cynanchum palustre	1	1	2
Lepidium virginicum	--	2	1
Strophostyles helvola	--	1	2
Juncus roemerianus	--	--	11
Festuca octoflora	--	--	2
Hydrocotyle verticillata	--	--	19

Table 7

Importance Values of Plant Species Occurring

Along Transect 3, Island 36-14

Species	1976	1977	1983
Spartina patens	56	29	19
Heterotheca subaxillaris	45	25	27
Spartina alterniflora	37	16	14
Oenothera humifusa	34	8	15
Distichlis spicata	27	39	1
Borrichia frutescens	--	50	17
Oenothera laciniata	--	19	--
Triplasis purpurea	--	8	22
Atriplex patula	--	8	--
Erigeron canadensis	--	--	19
Lepidium virginicum	--	--	16
Andropogon virginicus	--	--	14
Commelina communis	--	--	10
Panicum virgatum	--	--	7
Myrica cerifera	--	--	4
Solidago sempervirens	--	--	4
Baccharis halimifolia	--	--	3
Limonium carolinianum	--	--	3
Lactuca spp.	--	--	2
Prunus serotina	--	--	1
Salicornia virginica	--	--	1
Aster tenuifolius	--	--	1

Table 8

Importance Values of Plant Species Occurring Along Transect 1, Island 36-13

Species	1976	1977	1983
Spartina patens	33	21	26
Myrica cerifera	19	35	20
Heterotheca subaxillaris	11	4	7
Physalis viscosa	10	3	--
Commelina communis	9	5	4
Smilax auriculata	9	4	10
Andropogon virginicus	9	10	4
Ipomea sagittata	7	5	14
Ambrosia artemisiifolia	6	9	5
Erigeron canadensis	6	3	3
Fimbristylis castanea	6	7	5
Lippia nodiflora	5	7	5
Chloris petrea	5	5	1
Lythrum lineare	5	3	3
Oenothera humifusa	5	4	4
Eupatorium capillifolium	5	1	1
Erigeron spp.	4	6	--
Panicum virgatum	4	7	6
Spartina alterniflora	3	1	4
Solidago altissima	3	--	--
Solidago sempervirens	3	6	--
Baccharis angustifolia	3	1	--
Hydrocotyle verticillata	2	4	15
Aster tenuifolius	2	--	--
Borrichia frutescens	2	3	--
Lactuca canadensis	2	0*	--
Lepidium virginicum	2	1	4
Aristida stricta	2	--	--
Typha angustifolia	1	2	2
Agalinis spp.	1	3	1
Salix nigra	1	3	1
Unidentified grass	1	--	--
Eragrostis capillaris	1	1	--
Uniola paniculata	1	0	--
Triplasis purpurea	1	4	1

(Continued)

* An entry of 0 indicates the importance value was less than 1.

Table 8 (Continued)

Species	1976	1977	1983
Limonium carolinianum	1	1	1
Oenothera biennis	1	0	--
Juncus megacephalus	1	6	3
Strophostyles helvola	1	4	6
Salicornia virginica	1	1	1
Gnaphalium purpureum	1	--	--
Carduus spp.	1	--	--
Baccharis halimifolia	1	0	1
Irisine rhizomatosa	0	1	1
Erechtites heiracifolia	0	--	1
Sabatia stellaris	0	3	--
Hypericum spp.	0	--	--
Ludwigea palustris	0	--	--
Cynodon dactylon	0	--	--
Phragmites australis	0	--	1
Unidentified grass	0	--	--
Verbena scabra	0	--	--
Commelina virginica	0	--	--
Ptilimnium capillaceum	--	--	--
Scirpus americana	--	1	--
Yucca filamentosa	--	2	3
Festuca octiflora	--	1	--
Panicum amarum	--	1	2
Galium sp.	--	1	--
Unidentified herb	--	1	2
Rumex acetosella	--	0	--
Pinus taeda	--	0	1
Spiranthes vernalis	--	0	--
Cakile edentula	--	0	--
Rubus flagillaris	--	--	12
Chenopodium ambrosioides	--	--	6
Carex albolutescens	--	--	3
Vitis rotundifolia	--	--	3
Ampelopsis arborea	--	--	1

(Continued)

Table 8 (Concluded)

Species	1976	1977	1983
Solanum americanum	--	--	1
Unidentified grass	--	--	1
Andropogon scoparius	--	--	1
Cyperus spp.	--	--	1
Lactuca spp.	--	--	1
Asplenium platyneuron	--	--	1

Table 9

Importance Values of Plant Species Occurring

Along Transect 2, Island 36-13

Species	1977	1983
Spartina patens	66	22
Heterotheca subaxillaris	21	18
Ambrosia artemisiifolia	17	12
Smilax auriculata	15	17
Triplasis purpurea	13	21
Oenothera humifusa	10	12
Erigeron canadensis	9	11
Chloris petrea	8	9
Fimbristylis castanea	8	12
Lepidium virginicum	6	3
Oenothera laciniata	5	--
Andropogon spp.	4	5
Panicum amarum	4	2
Physalis viscosa	2	1
Poa spp.	2	--
Strophostyles helvola	2	1
Knaphalium purpureum	2	--
Erigeron spp.	1	--
Solidago sempervirens	1	4
Panicum virgatum	1	--
Galium hispidulum	1	3
Diodia teres	1	--
Rubus flagellaris	--	15
Ipomea sagittata	--	7
Parthenocissus quinquefolia	--	6
Agalinis spp.	--	4
Commelina communis	--	4
Sphenopholis obtusata	--	3
Lactuca spp.	--	3
Andropogon ternarius	--	2
Myrica cerifera	--	1
Juncus megacephalus	--	1
Eupatorium capillifolium	--	1
Carduus lanceolatus	--	1
Asplenium platyneuron	--	1

Table 10

Importance Values of Plant Species Occurring

Along Transect 3, Island 36-13

Species	1976	1983
Spartina patens	40	15
Yucca filamentosa	22	--
Panicum amarum	19	10
Triplasis purpurea	17	18
Erigeron canadensis	14	11
Lippia nodiflora	12	--
Oenothera humifusa	10	10
Commelina communis	9	11
Heterotheca subaxillaris	8	7
Borrichia frutescens	8	5
Fimbristylis castanea	7	--
Spartina alterniflora	6	8
Distichlis spicata	5	2
Aster tenuifolius	3	--
Panicum virgatum	3	5
Cynanchum palustre	2	--
Euphorbia polygonifolia	2	1
Unidentified seedling	1	--
Agalinis spp.	1	--
Galium hispidulum	1	--
Uniola paniculata	1	--
Chloris petrea	1	--
Andropogon virginicus	1	--
Limonium carolinianum	1	1
Strophostyles helvola	1	1
Cyperus compressus	1	--
Salicornia virginica	1	5
Solidago sempervirens	1	--
Erigeron spp.	1	--
Ambrosia artemisiifolia	1	7
Ipomoea sagittata	--	35
Hydrocotyle verticillata	--	19
Chenopodium ambrosioides	--	9
Lepidium virginicum	--	7
Teucrium canadense	--	6

(Continued)

Table 10 (Concluded)

Species	1976	1983
Parthenocissus quinquefolia	--	3
Iva frutescens	--	3
Festuca rubra	--	1

Table 11

Importance Values of Plant Species Occurring Along Transect 1, Island 28-01

Species	1976	1977	1983
Aster subulatus	96	28	--
Baccharis halimifolia	26	79	51
Iva frutescens	14	12	9
Erigeron canadensis	13	7	1
Eupatorium capillifolium	10	9	--
Toxicodendron radicans	6	3	68
Eupatorium serotinum	6	3	--
Spartina patens	4	3	--
Myrica cerifera	4	7	11
Erigeron spp.	4	4	--
Solidago sempervirens	3	5	--
Ampelopsis arborea	2	2	10
Galium tinctorum	2	2	--
Poa spp.	2	2	--
Solidago altissima	2	1	4
Ambrosia artemisiifolia	1	1	--
Borrichia frutescens	1	--	--
Carduus spp.	1	--	--
Mikania scandens	1	1	--
Sambucus canadensis	1	--	--
Ipomoea sagittata	1	--	--
Cyperus filicinus	1	--	--
Strophostyles helvola	1	--	--
Kosteletzkya virginica	1	--	--
Andropogon virginicus	1	--	9
Distichlis spicata	1	1	--
Setaria geniculata	1	--	--
Salix nigra	1	--	--
Verbena braziliensis	1	--	--
Parthenocissus quinquefolia	1	3	4
Ptilimnium capillaceum	--	6	--
Spartina cynosuroides	--	4	--
Sonchus oleraceus	--	4	--
Erechtites heiracifolia	--	3	--

(Continued)

Table 11 (Concluded)

Species	1976	1977	1983
Polygonum spp.	--	3	1
Unidentified herb	--	1	--
Fimbristylis castanea	--	2	--
Verbena spp.	--	1	--
Galium hispidulum	--	1	--
Rubus flagillaris	--	1	2
Phytolacca americana	--	1	4
Sonchus asper	--	1	--
Acer rubrum	--	1	--
Rubus argutus	--	--	9
Acalypha rhomboidea	--	--	4
Ilex vomitoria	--	--	4
Panicum laxiflorum	--	--	2
Festuca rubra	--	--	2
Elymus virginicus	--	--	2
Lonicera japonica	--	--	2
Juniperus virginiana	--	--	1
Juncus coriaceus	--	--	1
Hypericum stans	--	--	1
Polygonum persicaria	--	--	1
Rubus flagellaris	--	--	1

Table 12

Importance Values of Plant Species Occurring

Along Transect 1, Island 22-26

Species	1976	1983
Distichlis spicata	64	15
Spartina alterniflora	39	5
Spartina patens	21	55
Borrichia frutescens	21	6
Juncus roemerianus	15	10
Iva frutescens	7	1
Atriplex patula	6	--
Salicornia virginica	5	3
Phytolacca americana	4	--
Ampelopsis arborea	3	--
Triplasis purpurea	3	17
Eleusine indica	3	--
Chloris petrea	3	--
Commelina communis	3	--
Solidago sempervirens	3	4
Heterotheca subaxillaris	--	21
Oenothera humifusa	--	19
Erigeron canadensis	--	11
Euphorbia polygonifolia	--	10
Limonium carolinianum	--	8
Cenchrus tribuloides	--	7
Panicum virgatum	--	3
Chenopodium ambrosioides	--	2
Toxicodendron radicans	--	2
Aster tenuifolius	--	1

Table 13

Importance Values of Plant Species Occurring

Along Transect 1, Island 22-25

Species	1976	1977	1983
Borrichia frutescens	41	23	10
Iva frutescens	37	22	10
Spartina patens	35	59	95
Strophostyles helvola	15	2	9
Solidago sempervirens	14	8	4
Paspalum distichum	12	--	27
Distichlis spicata	10	20	--
Salicornia virginica	6	2	2
Fimbristylis castanea	6	8	--
Setaria geniculata	5	--	--
Panicum virgatum	5	7	4
Spartina alterniflora	4	--	--
Erigeron canadensis	4	10	--
Aster tenuifolius	3	--	--
Juncus roemerianus	2	--	2
Atriplex patula	2	4	--
Festuca rubra	--	18	27
Heterotheca subaxillaris	--	6	--
Ptilimnium capillaceum	--	3	--
Baccharis halimifolia	--	2	--
Sabatia stellaris	--	2	--
Andropogon virginicus	--	2	7
Unidentified herb	--	2	--
Galium tinctorium	--	--	2

Table 14

Importance Values of Plant Species Occurring

Along Transect 2, Island 22-25

Species	1976	1977	1983
Solidago sempervirens	42	31	3
Baccharis halimifolia	29	3	--
Paspalum distichum	25	28	--
Atriplex patula	22	9	--
Spartina patens	13	19	40
Setaria geniculata	9	3	--
Spartina alterniflora	8	6	23
Cyperus compressus	7	8	--
Heterotheca subaxillaris	7	24	10
Eupatorium capillifolium	7	1	--
Erigeron canadensis	7	16	3
Strophostyles helvola	5	5	9
Cyperus spp.	5	--	--
Boehmeria cylindrica	2	--	3
Galium spp.	2	1	--
Oenothera humifusa	2	3	3
Fimbristylis castanea	2	--	--
Sueda linearis	2	--	--
Erigeron spp.	2	3	--
Irisine rhizomatosa	2	--	--
Ptilimnium capillaceum	--	16	--
Iva frutescens	--	7	20
Salicornia virginica	--	4	12
Ambrosia artemisiifolia	--	3	--
Galium tinctorium	--	1	--
Vitis spp.	--	1	--
Oenothera laciniata	--	1	--
Sabatia stellaris	--	1	--
Euphorbia polygonifolia	--	1	--
Carex albolutescens	--	1	5
Myrica cerifera	--	--	17
Distichlis spicata	--	--	15
Rubus flagellaris	--	--	10
Stenotaphorum secundutum	--	--	9
Borrichia frutescens	--	--	8
Triplasis purpurea	--	--	3

(Continued)

Table 14 (Concluded)

Species	1976	1977	1983
Panicum virgatum	--	--	3
Andropogon virginicus	--	--	3
Rhus radicans	--	--	3

Table 15

Importance Values of Plant Species Occurring

Along Transect 3, Island 22-25

Species	1976	1977	1983
Paspalum distichum	35	17	--
Spartina patens	31	27	30
Iva frutescens	29	5	--
Panicum virgatum	11	12	9
Fimbristylis castanea	11	6	6
Chenopodium ambrosioides	10	9	--
Ambrosia artemisiifolia	9	--	--
Spartina alterniflora	7	11	--
Distichlis spicata	6	--	--
Solidago sempervirens	6	17	--
Borrichia frutescens	5	14	--
Andropogon virginicus	4	2	--
Strophostyles helvola	4	--	--
Atriplex patula	4	5	--
Setaria geniculata	2	4	--
Festuca rubra	2	15	--
Phytolacca americana	2	--	--
Oenothera biennis	2	--	--
Kosteletzkya virginica	2	--	--
Cyperus spp.	2	--	2
Baccharis halimifolia	2	4	--
Cynanchum palustre	1	--	--
Lactuca spp.	1	--	--
Cyperus compressus	1	5	--
Sabatia stellaris	1	--	2
Chloris petrea	1	2	5
Triplasis purpurea	1	--	32
Physalis viscosa	1	2	2
Heterotheca subaxillaris	--	15	36
Erigeron canadensis	--	13	28
Aster subulatus	--	7	--
Digitaria sanguinalis	--	4	--
Baccharis halimifolia	--	4	--
Limonium carolinianum	--	2	--
Galium tinctorium	--	1	--

(Continued)

Table 15 (Concluded)

Species	1976	1977	1983
Rumex verticillatus	--	1	--
Stellaria media	--	1	--
Pyrrhopappus caroliniana	--	1	--
Lactuca canadensis	--	1	--
Eupatorium capillifolium	--	1	--
Oenothera humifusa	--	--	26
Andropogon virginicus	--	--	12
Myrica cerifera	--	--	6
Euphorbia polygonifolia	--	--	6
Sesuvium portulacastrum	--	--	2

Table 16

Importance Values of Plant Species Occurring

Along Transect 4, Island 22-25

Species	1977	1983
Iva frutescens	78	--
Spartina patens	32	71
Spartina alterniflora	28	4
Digitaria sanguinalis	26	--
Distichlis spicata	10	--
Paspalum distichum	5	--
Triplasis purpurea	4	10
Strophostyles helvola	4	--
Chenopodium ambrosioides	4	--
Solidago sempervirens	4	10
Heterotheca subaxillaris	4	27
Erigeron canadensis	--	19
Oenothera humifusa	--	15
Lepidium virginicum	--	15
Ambrosia artemisiifolia	--	6
Physalis viscosa	--	5
Cyperus spp.	--	4
Atriplex patula	--	4
Borrichia frutescens	--	4
Salicornia virginica	--	2
Euphorbia polygonifolia	--	2
Unidentified herb	--	2

Table 17

Numbers of Nests of Ground Nesting Colonial Waterbirds by Colony Site Type in North Carolina Estuaries in 1977 and 1983

Species	Total Number of Nests		Barrier Beach		Dredged Material				Natural Estuarine		Other	
					Not Diked		Diked					
	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983
Brown pelican	82	1,328	00	00	00	577	00	00	00	751	82	00
Laughing gull	9,369	22,903	00	00	5,016	6,363	117	9,860	4,235	6,680	00	00
Herring gull	433	444	00	00	412	302	00	00	09	91	12	51
Gull-billed tern	268	223	75	04	72	63	121	155	00	00	00	00
Royal tern	9,755	17,029	00	00	7,302	13,535	1,061	3,072	1,390	422	00	00
Sandwich tern	1,190	1,850	00	00	972	892	124	958	94	00	00	00
Common tern	2,761	2,227	723	872	952	477	378	622	618	243	90	13
Forster's tern	1,138	931	155	63	58	207	54	00	812	661	59	00
Least tern	1,925	1,731	932	1,044	18	25	865	662	02	00	108	00
Black skimmer	976	733	506	279	362	184	76	184	32	86	00	00
Totals	27,897	49,399	2,391	2,262	15,166	22,626	2,796	15,513	7,193	8,934	351	64
Change	+21,502		-129		+7,460		+12,717		+1,741		-287	

Table 18

Numbers of Nests of Wading Birds by Colony Site Type

in North Carolina Estuaries in 1977 and 1983

Species	Total Number of Nests		Barrier Beach		Dredged Material				Natural Estuarine	
					Not Diked		Diked			
	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983
Little blue heron	802	1,164	00	00	633	692	38	272	131	200
Tri-colored heron	1,479	1,399	00	00	975	834	64	168	440	397
Black-crowned night heron	237	269	00	19	143	113	06	83	88	54
Green-backed heron	42	19	00	00	29	04	00	15	13	01
Great egret	494	839	00	28	281	415	09	14	204	383
Snowy egret	1,034	715	00	00	476	306	68	48	490	361
Cattle egret	1,137	1,448	00	00	643	204	00	518	494	726
White ibis	1,939	3,815	00	00	1,936	3,730	03	85	00	00
Glossy ibis	404	291	00	00	265	132	26	00	113	159
Total nests	7,568	9,959	00	47	5,381	6,430	214	1,203	1,973	2,281
Change 1977 to 1983	+2,391		+47		+1,049		+989		+308	

Table 19

Numbers of Colonies of Ground Nesting Waterbirds by Colony Site Type in North Carolina Estuaries in 1977 and 1983

Species	Total Number of Colonies		Barrier Beach		Dredged Material				Natural Estuarine		Other	
					Not Diked		Diked					
	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983
Brown pelican	02	03	00	00	00	02	00	00	00	01	02	00
Laughing gull	16	16	00	00	08	09	02	02	06	05	00	00
Herring gull	07	12	00	00	04	07	00	00	01	03	02	02
Gull-billed tern	09	09	03	01	04	03	02	05	00	00	00	00
Royal tern	07	08	00	00	04	06	02	01	01	01	00	00
Sandwich tern	05	07	00	00	03	06	01	01	01	00	00	00
Common tern	35	24	06	08	10	07	02	03	15	05	02	01
Forster's tern	26	13	03	01	02	02	01	00	18	10	02	00
Least tern	38	31	18	17	02	01	13	13	01	00	04	00
Black skimmer	17	14	07	04	07	05	01	03	02	02	00	00
Totals	162	137	37	31	44	48	24	28	45	27	12	03
Change 1977 to 1983	-25		-06		+04		+04		-18		-09	

Table 20

Numbers of Colonies of Wading Birds by Colony Site Type

in North Carolina Estuaries in 1977 and 1983

Species	Total Number of Colonies		Barrier Beach		Dredged Material				Natural Estuarine	
					Not Diked		Diked			
	1977	1983	1977	1983	1977	1983	1977	1983	1977	1983
Little blue heron	16	11	00	00	10	06	02	02	04	03
Tri-colored heron	18	16	00	00	09	08	02	03	07	05
Black-crowned night heron	13	13	00	01	09	06	01	02	03	04
Green-backed heron	05	02	00	00	04	01	00	01	01	00
Great egret	16	18	00	02	09	08	02	03	05	05
Snowy egret	18	14	00	00	09	06	02	03	07	05
Cattle egret	09	08	00	00	07	05	00	01	02	02
White ibis	02	05	00	00	01	04	01	01	00	00
Glossy ibis	12	07	00	00	06	03	02	00	04	04
Totals	109	94	00	03	64	47	12	16	33	28
Change 1977 to 1983	-15		+03		-17		+04		-05	

Table 21

Changes in Numbers of Sites, Colonies, and Nests of Colonial Waterbirds in North Carolina Estuaries between 1977 and 1983*

Sites	Gulls, Terns, and Pelicans		Herons, Egrets, and Ibises		Totals		Change 1977-1983	
	1977	1983	1977	1983	1977	1983	#	%
Barrier island								
Number of colonies	37	31	00	03	37	34	-03	-08
Number of nests	2,391	2,262	00	47	2,391	2,309	-82	-03
Natural estuarine								
Number of colonies	45	27	33	28	78	55	-23	-29
Number of nests	7,193	8,934	1,971	2,281	9,164	11,215	+2,051	+22
Dredged: Undiked								
Number of colonies	44	48	64	47	108	95	-13	-12
Number of nests	15,166	22,626	5,381	6,430	20,547	31,056	+10,509	+51
Dredged: Diked								
Number of colonies	24	28	12	16	36	44	+08	+22
Number of nests	2,796	15,513	214	1,203	3,010	16,716	+13,706	+455
Totals								
Sites	88	--	18	--	97	87	-10	--
Number of colonies	150	134	109	94	259	?28	-31	-12
Number of nests	27,546	49,335	7,566	9,961	35,112	61,296	+26,184	+74

* Sites listed as "other" in Tables 17 and 19 were not included in this analysis.

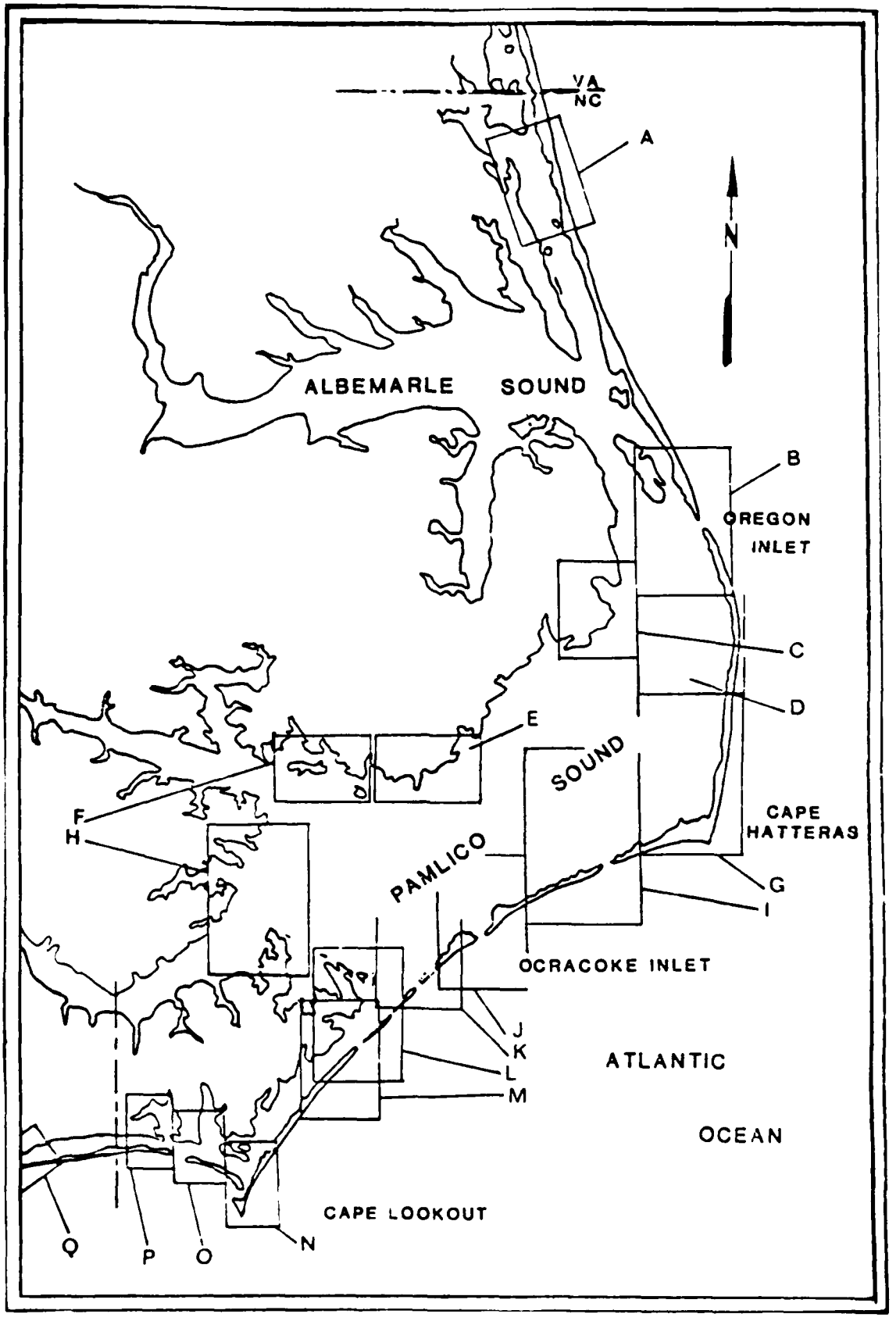

Figure 1. Index to Maps A through P

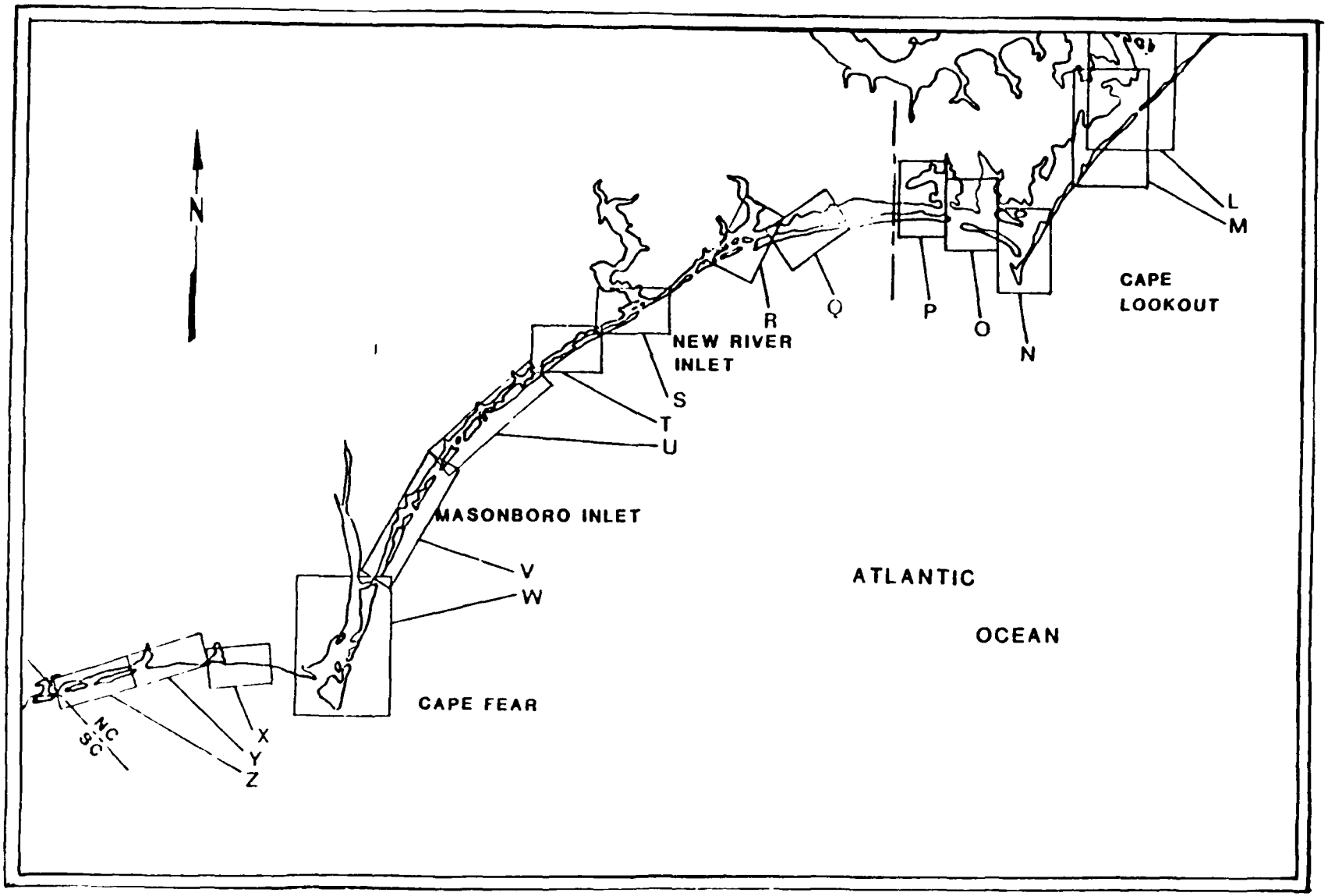

Figure 2. Index to Maps Q through Z

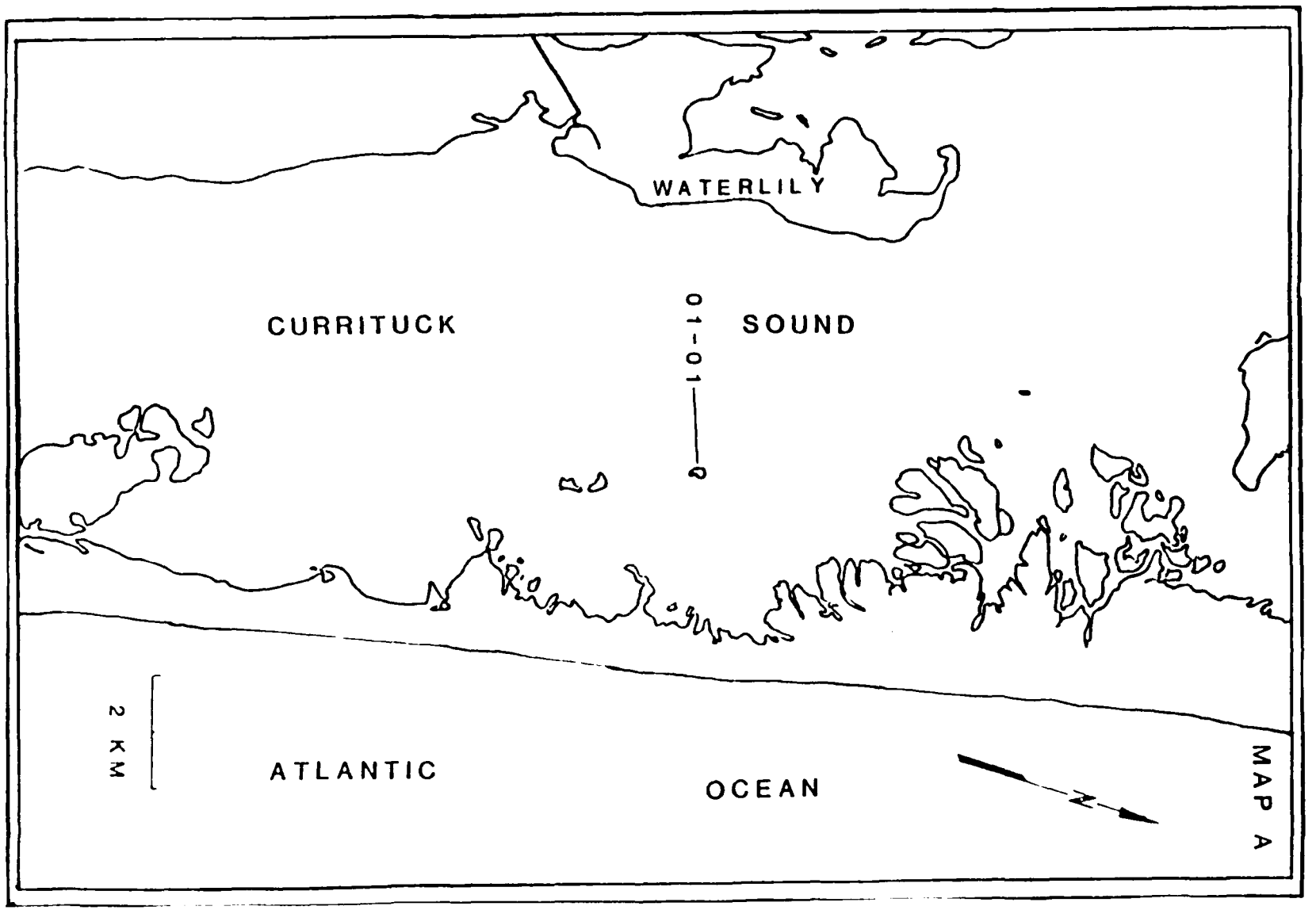

Figure 3. Map A, Currituck Sound

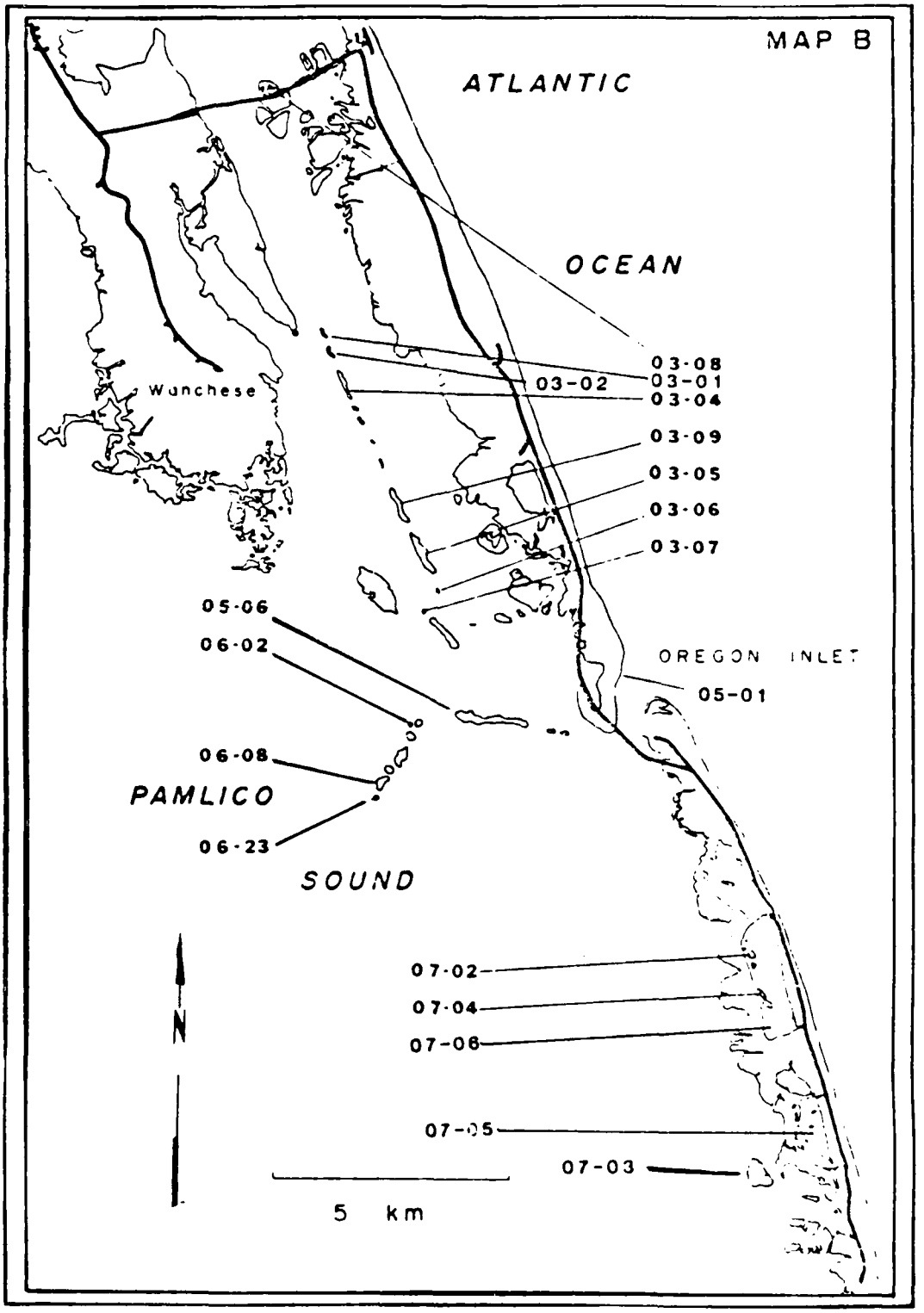

Figure 4. Map B, Oregon Inlet and vicinity

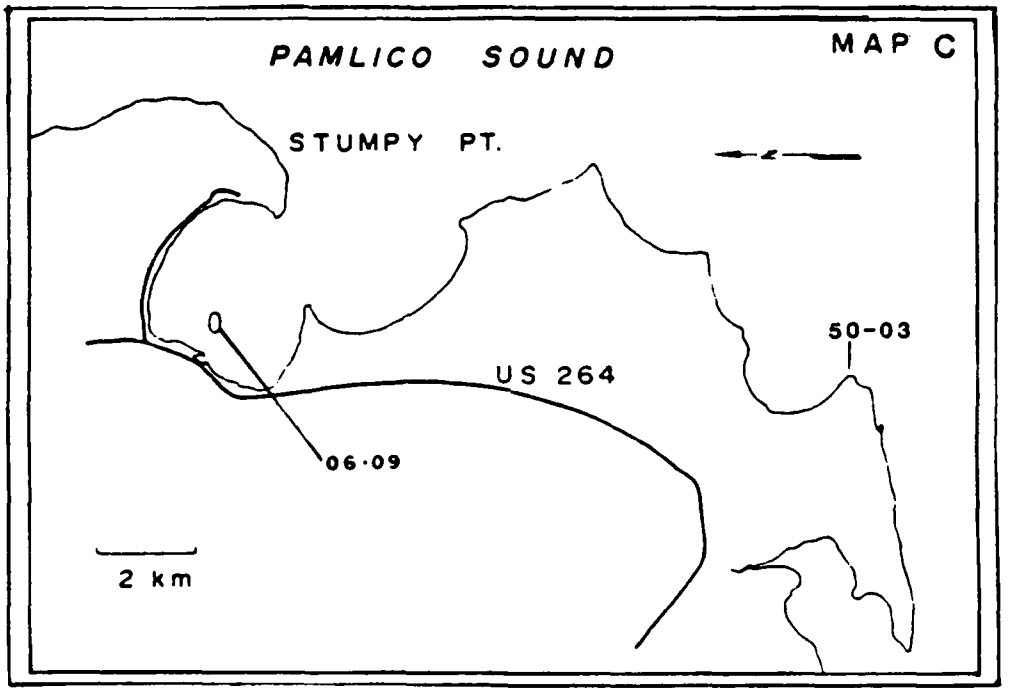

Figure 5. Map C, Stumpy Point and vicinity

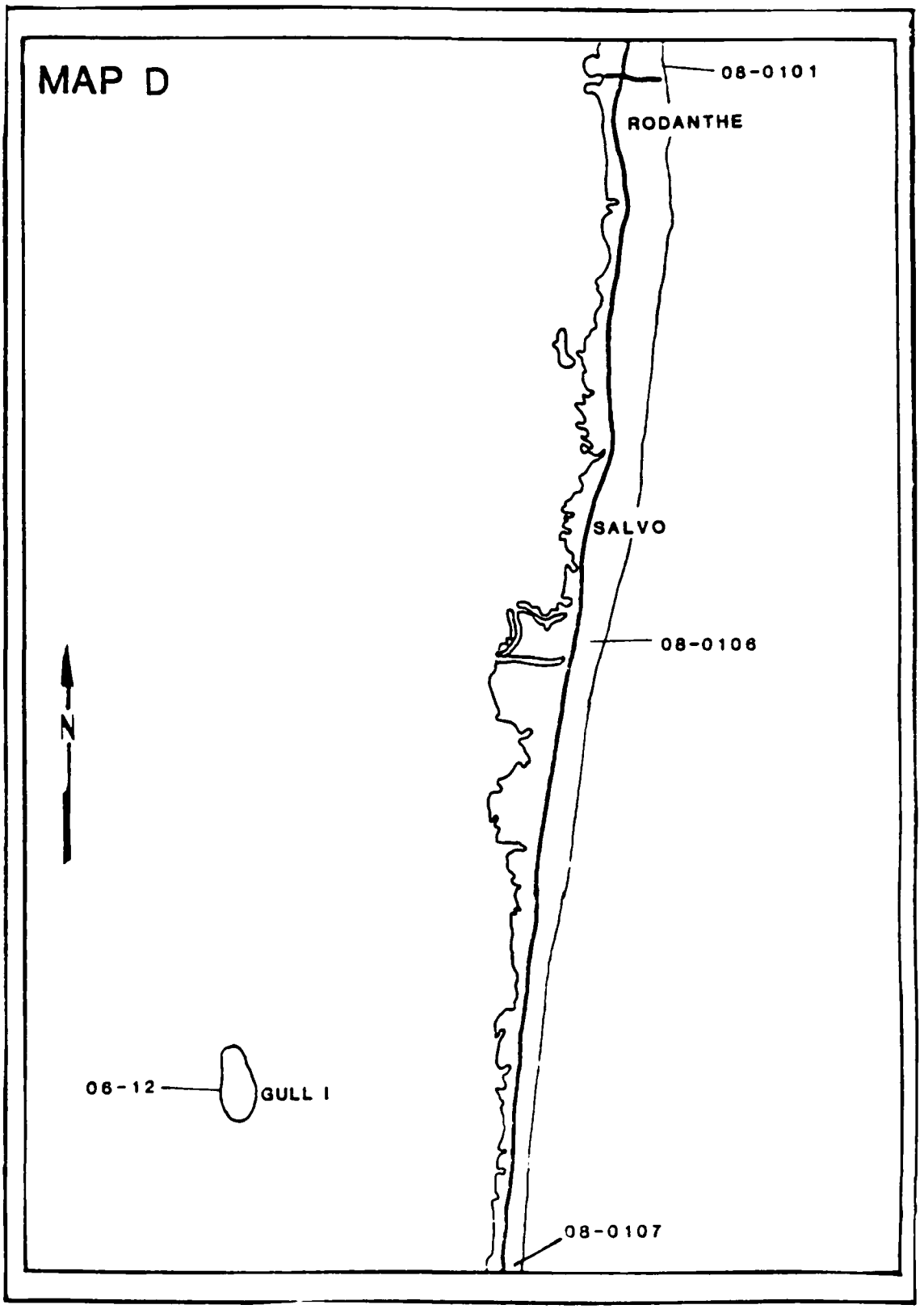

Figure 6. Map D, Salvo and vicinity

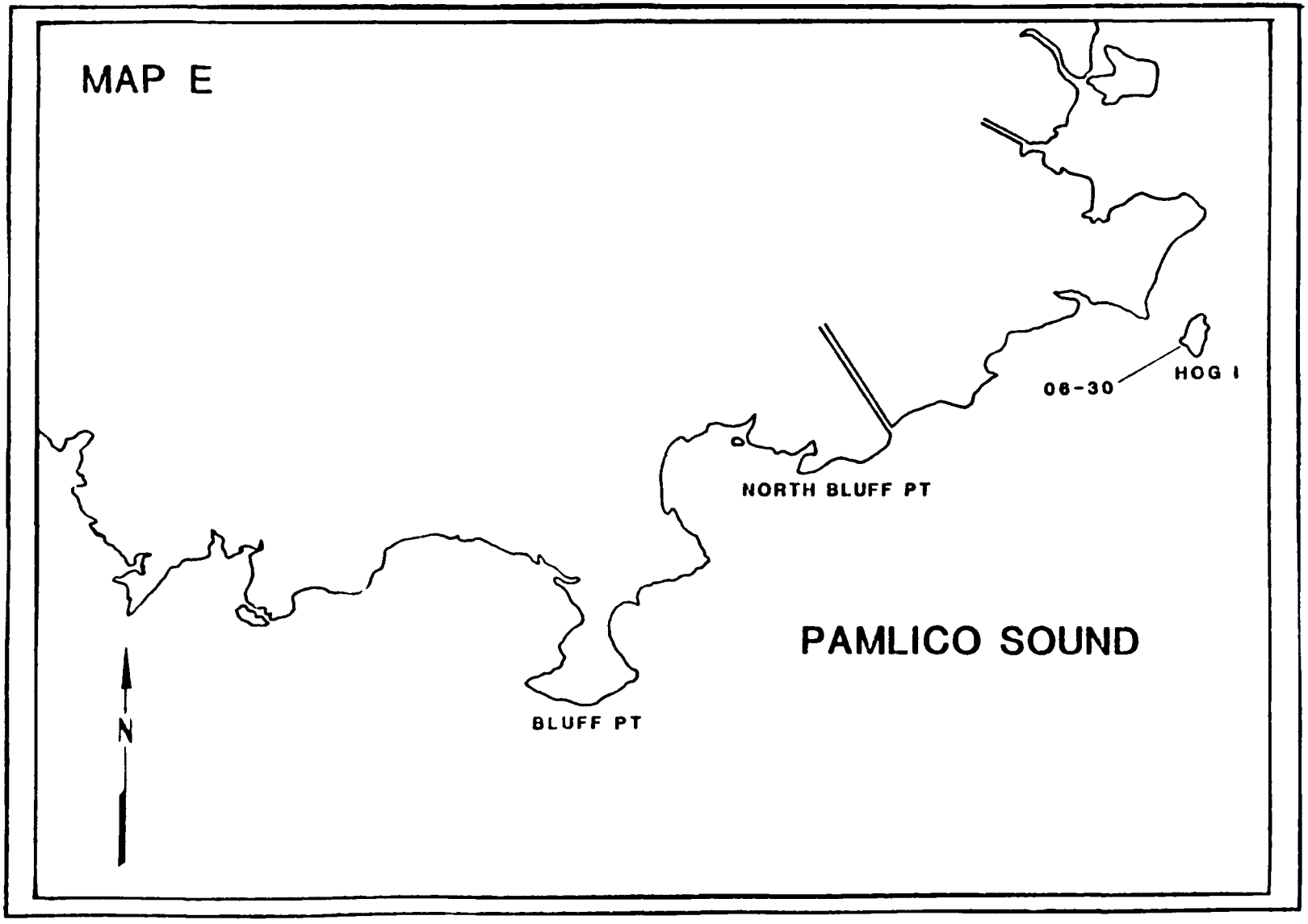

Figure 7. Map E, North Bluff Point and vicinity

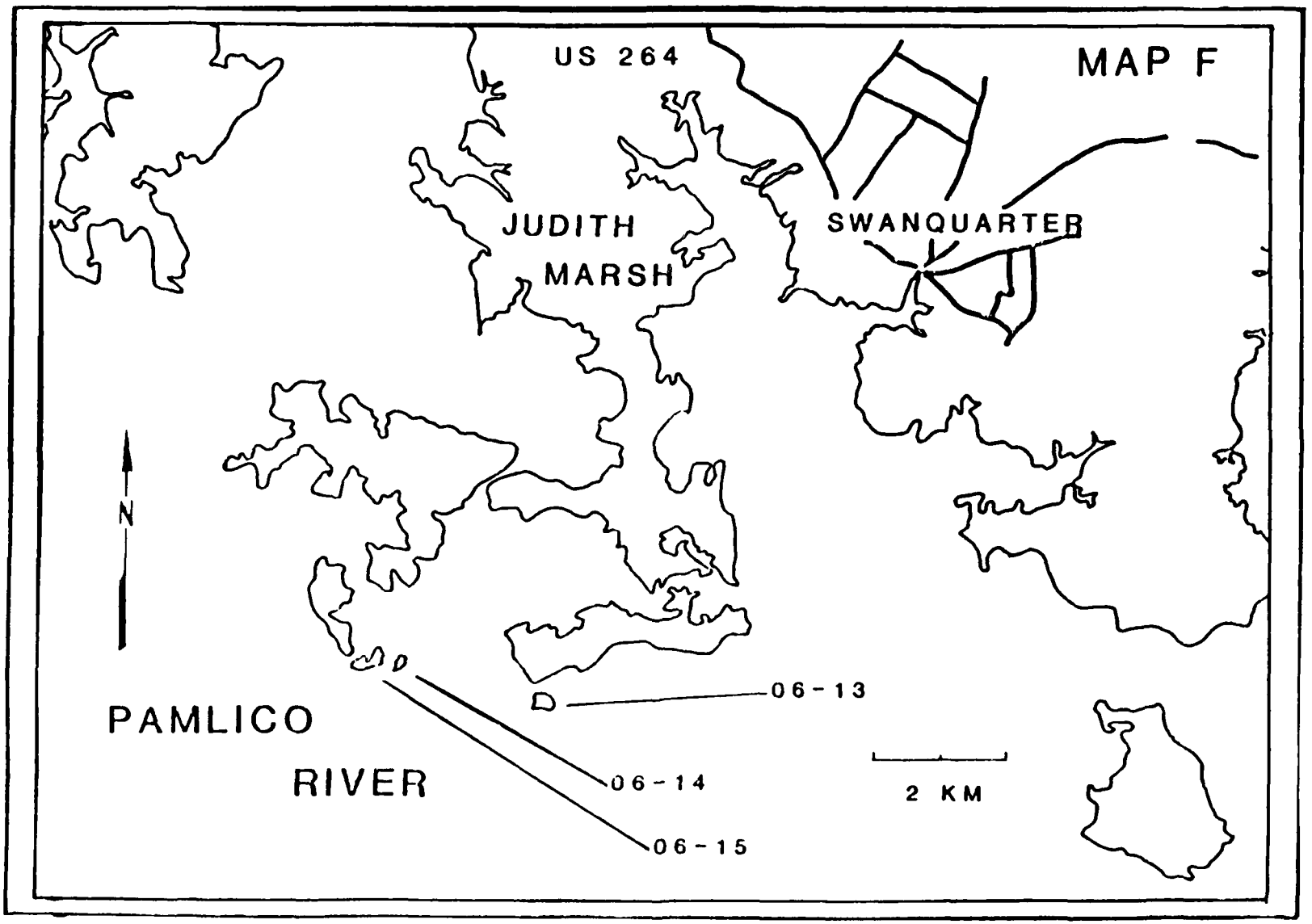

Figure 8. Map F, Judith marsh and vicinity

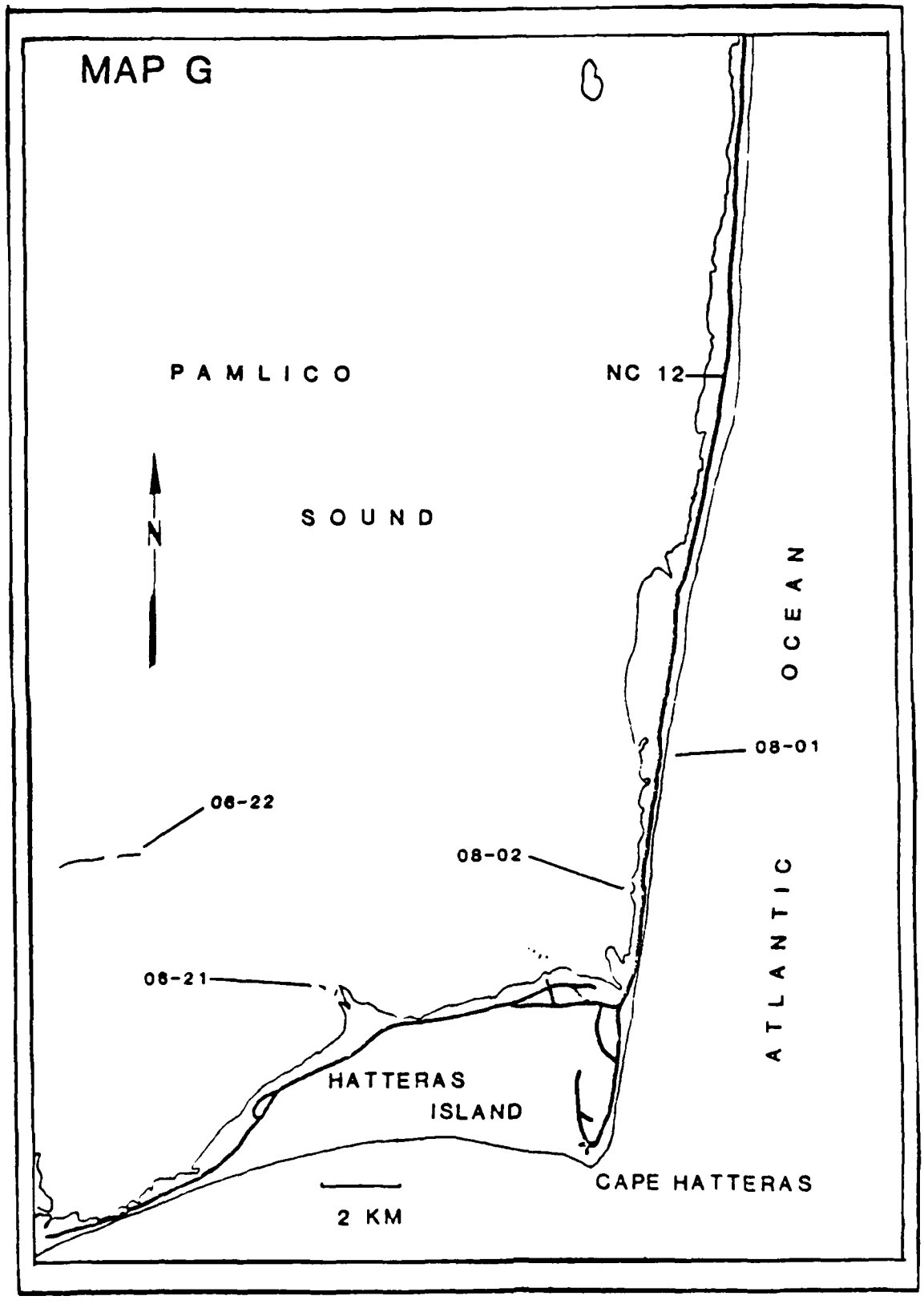

Figure 9. Map G, Cape Hatteras and vicinity

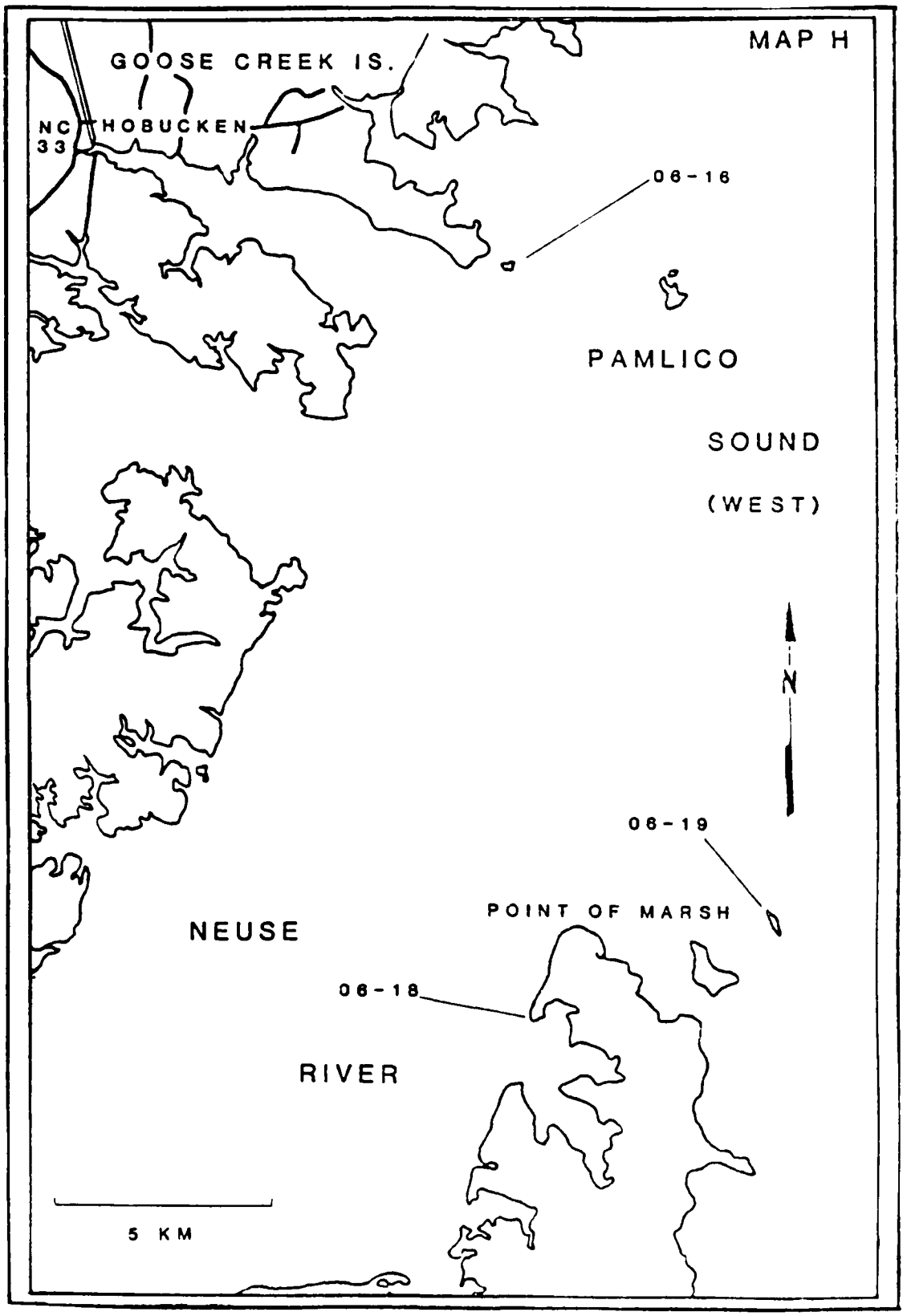

Figure 10. Map H, Neuse River mouth and vicinity

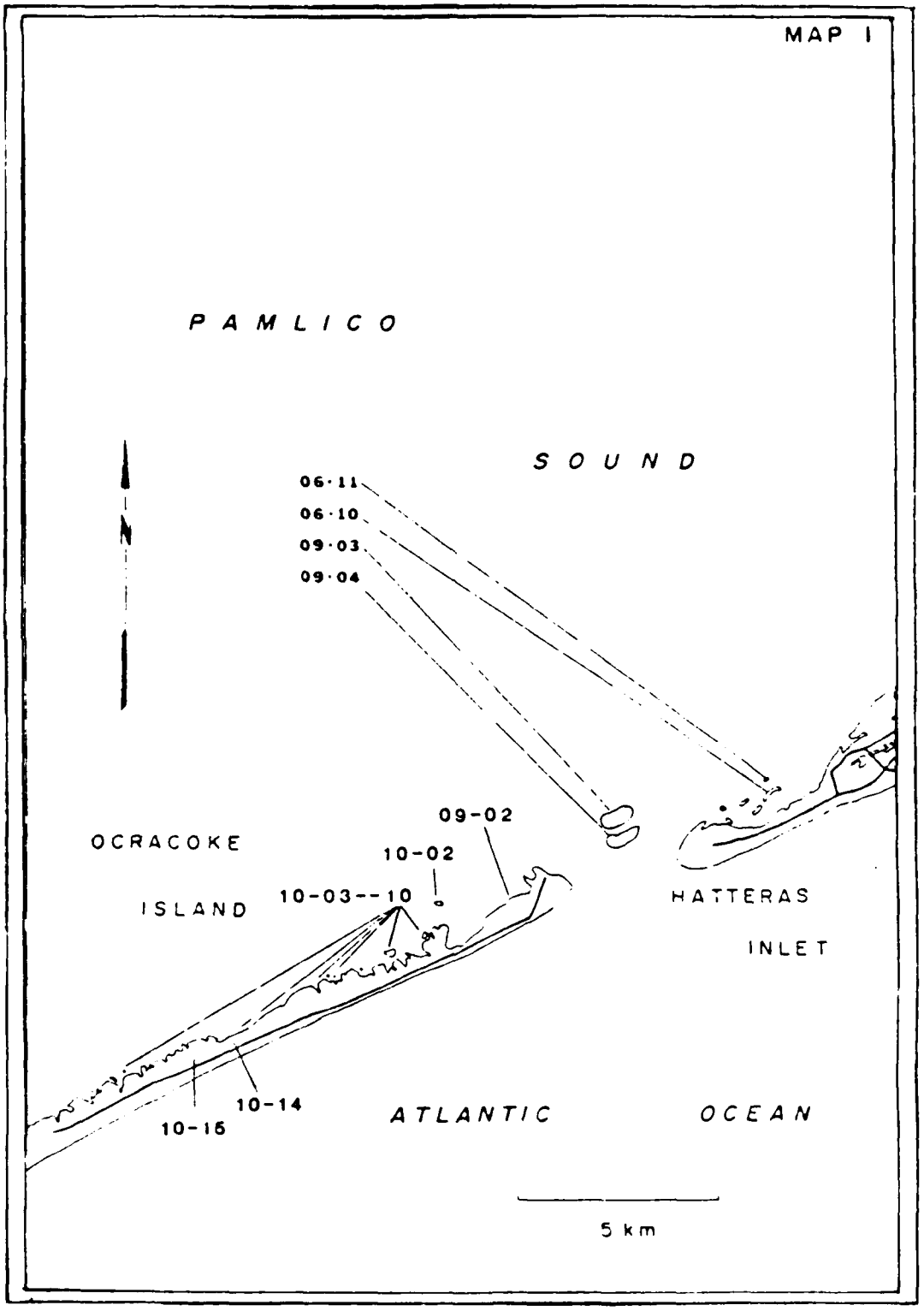

Figure 11. Map I, Hatteras Inlet and vicinity

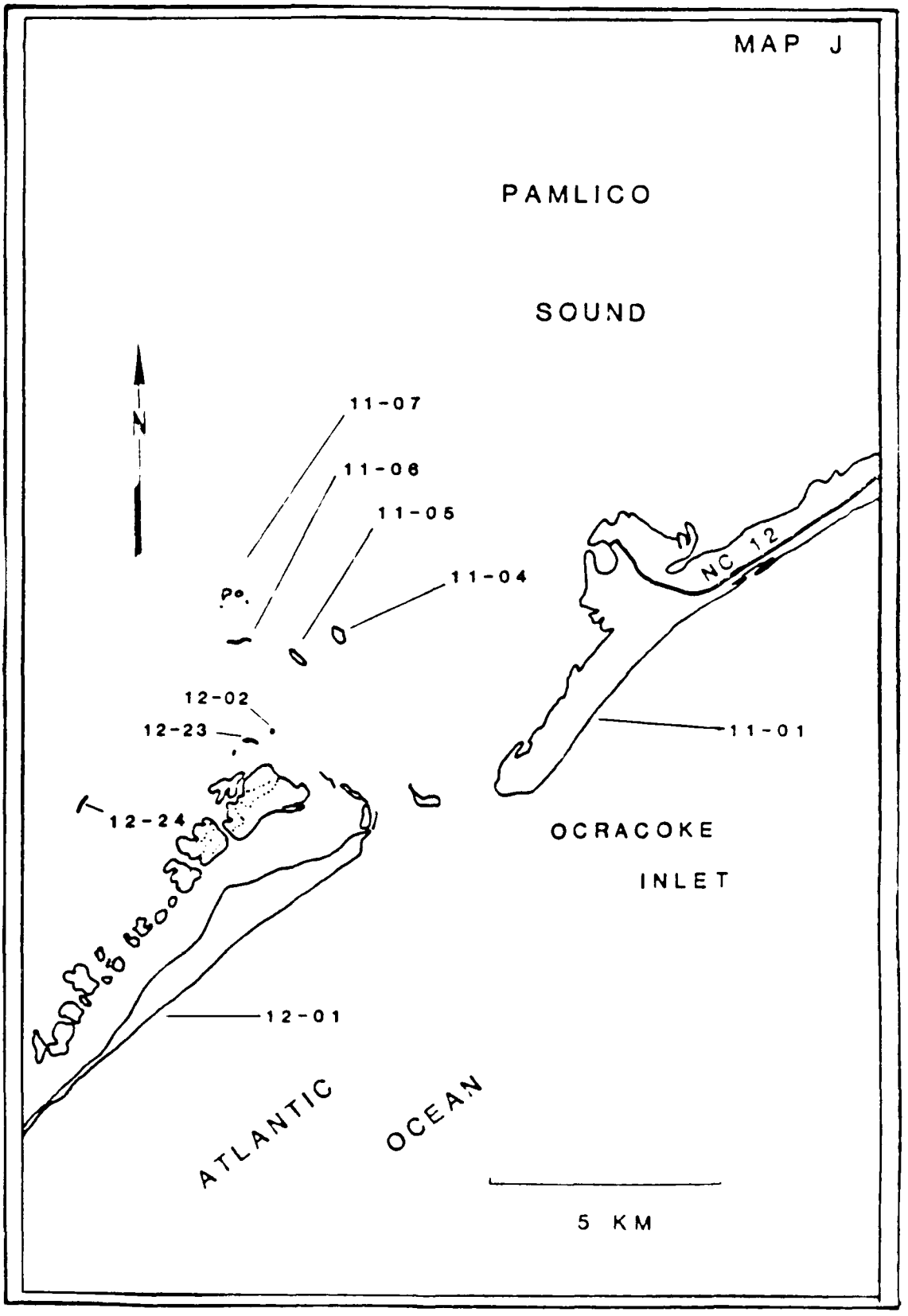

Figure 12. Map J, Ocracoke Inlet and vicinity

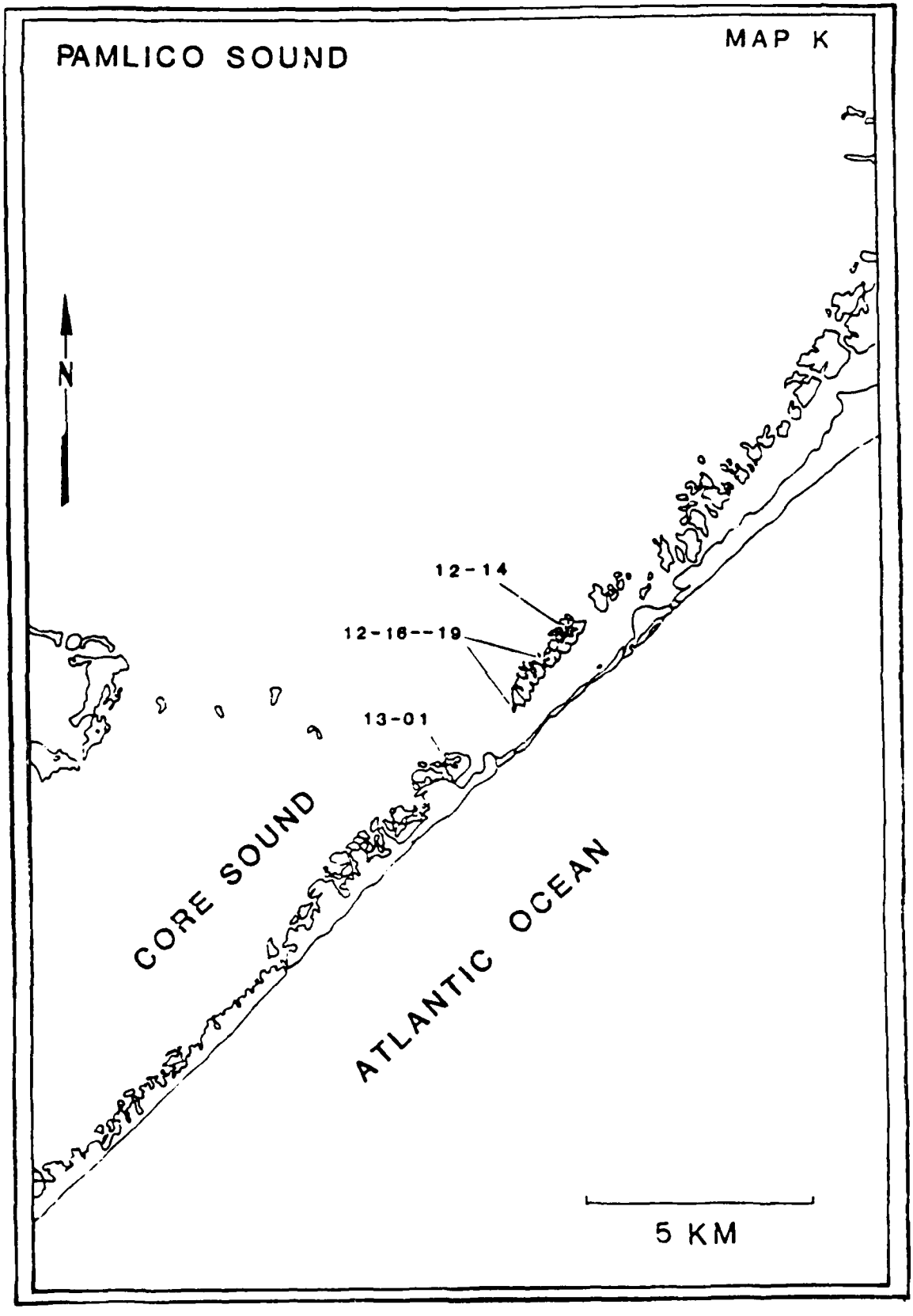

Figure 13. Map K, North Core Sound and vicinity

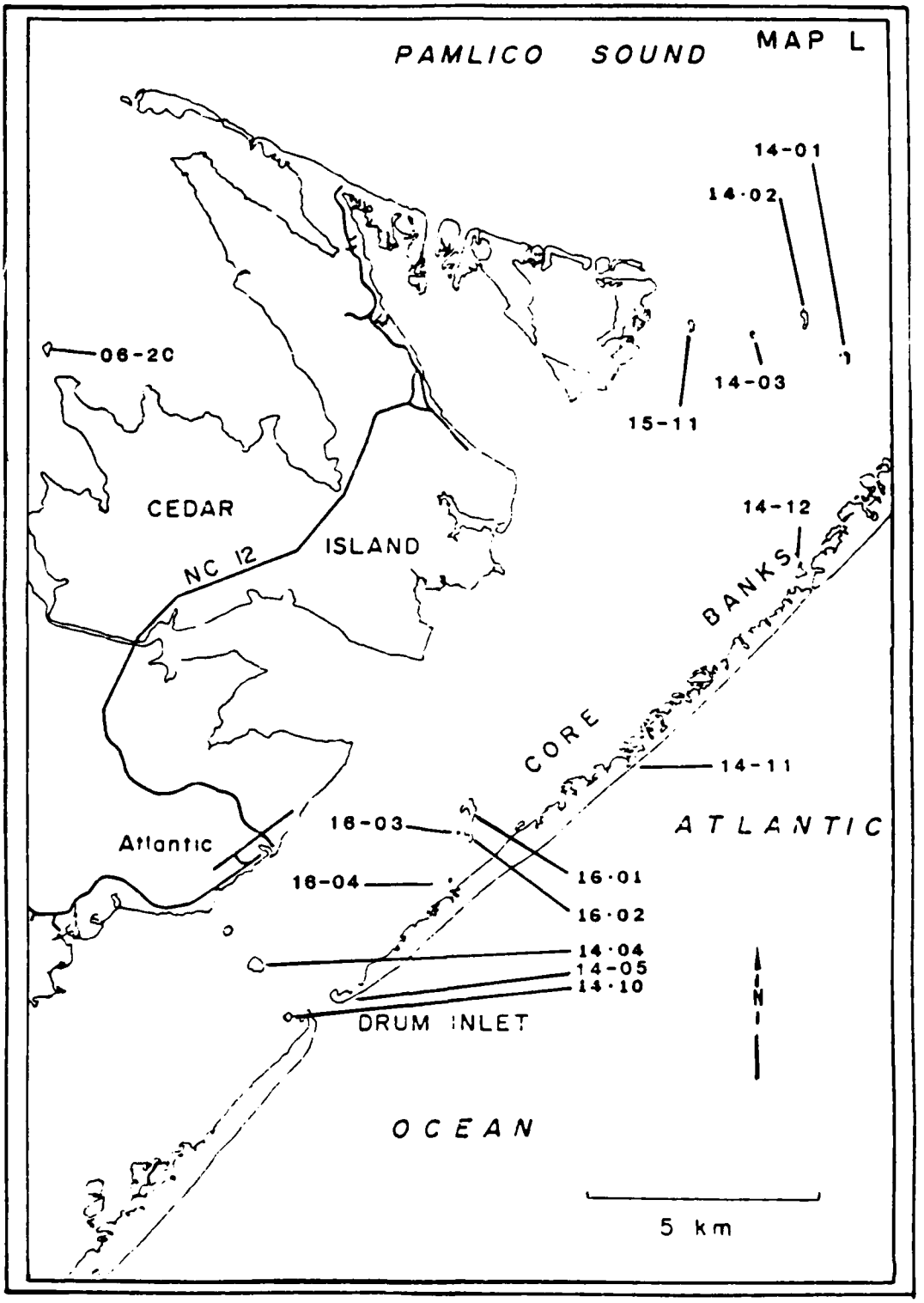

Figure 14. Map L, Drum Inlet and vicinity

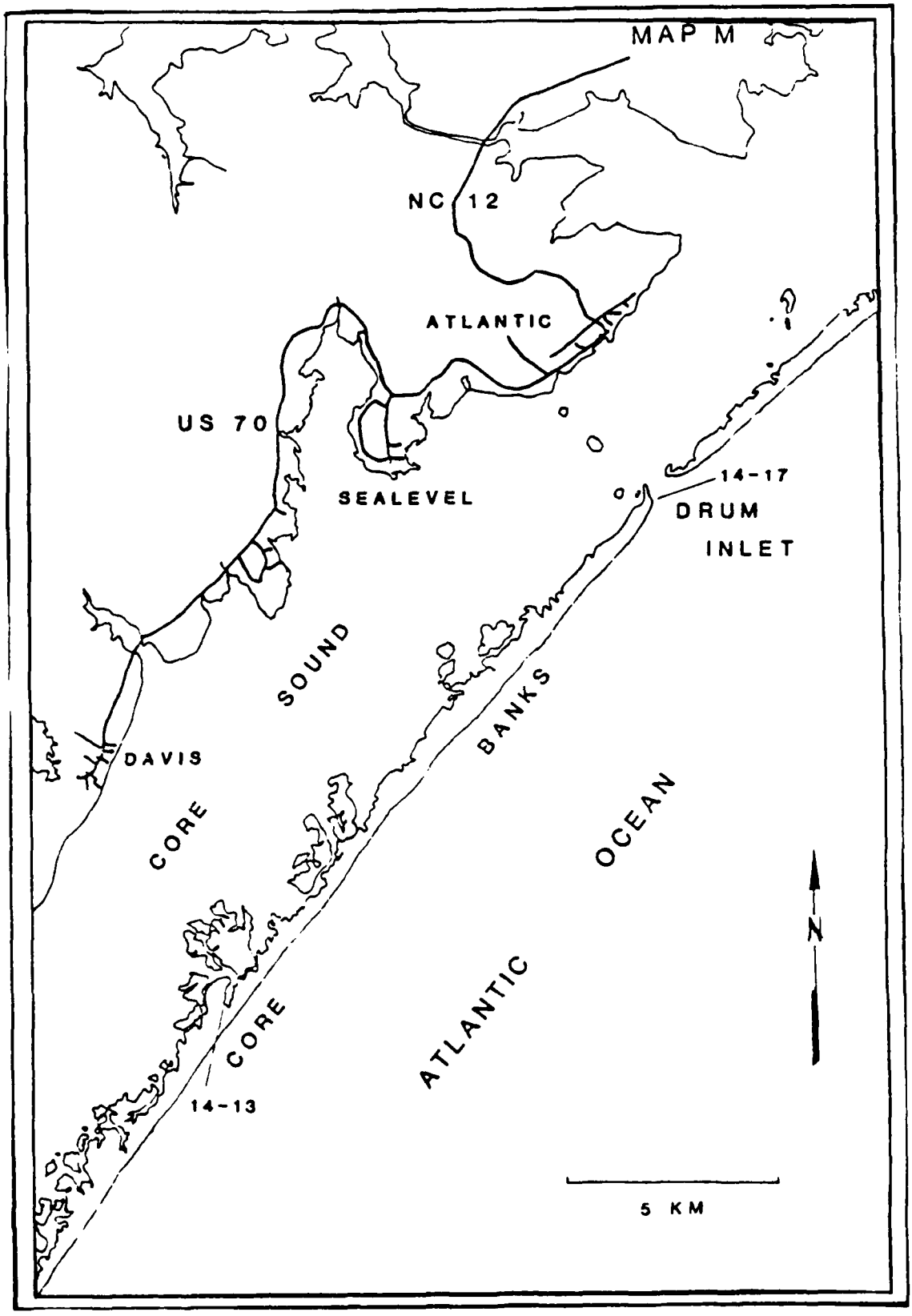

Figure 15. Map M, Davis and vicinity

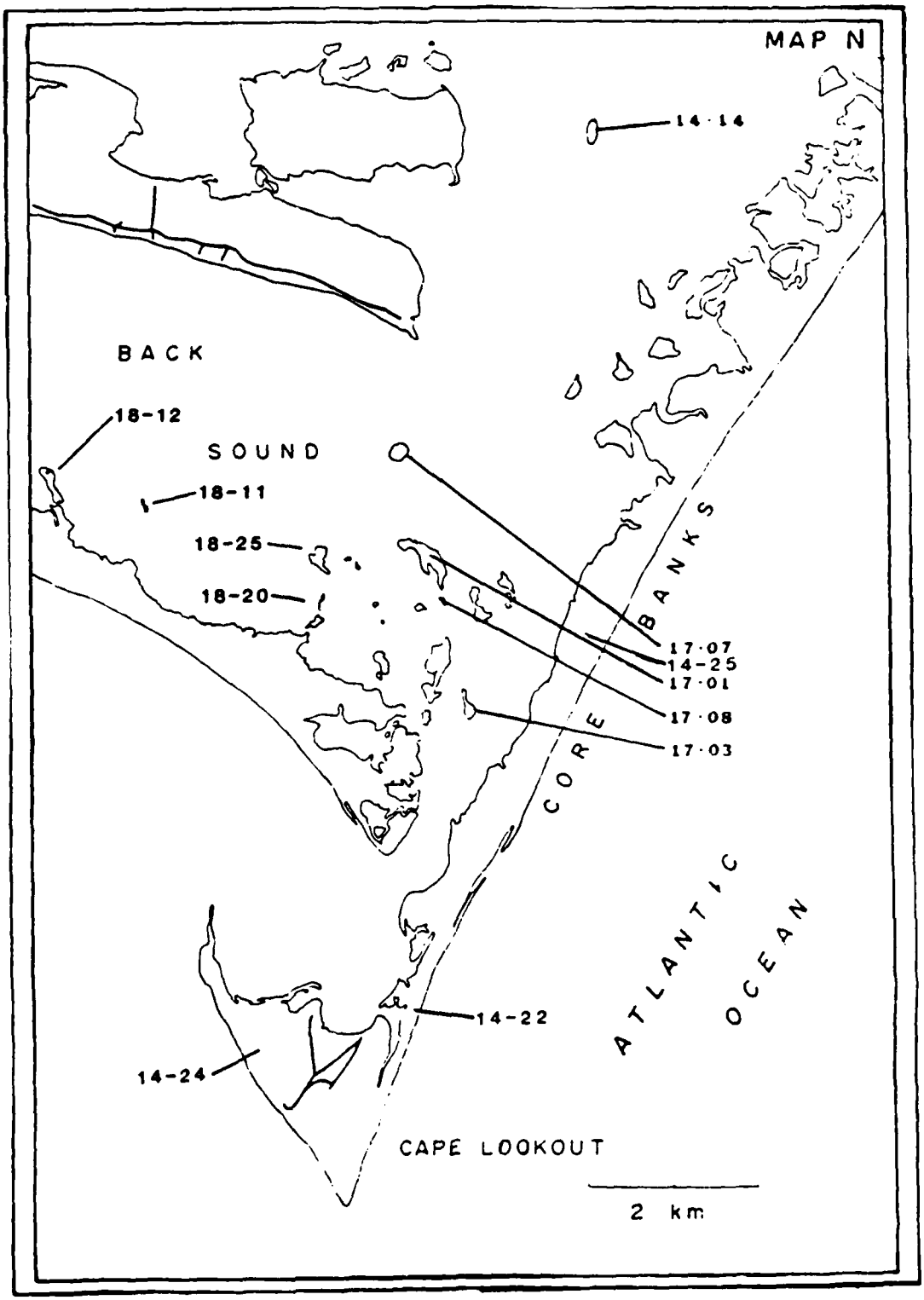

Figure 16. Map N, Back Sound and vicinity

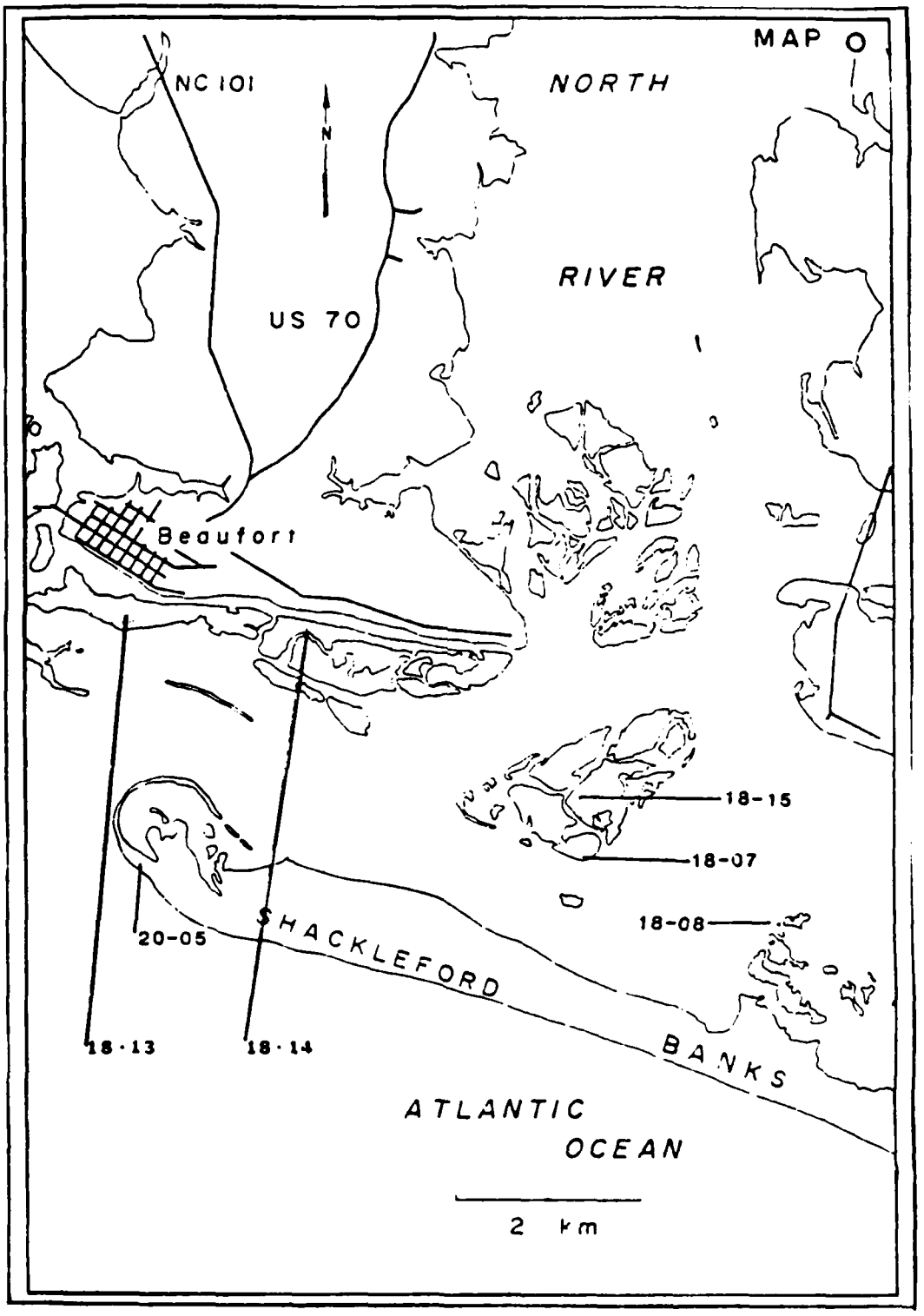

Figure 17. Map O, Beaufort and vicinity

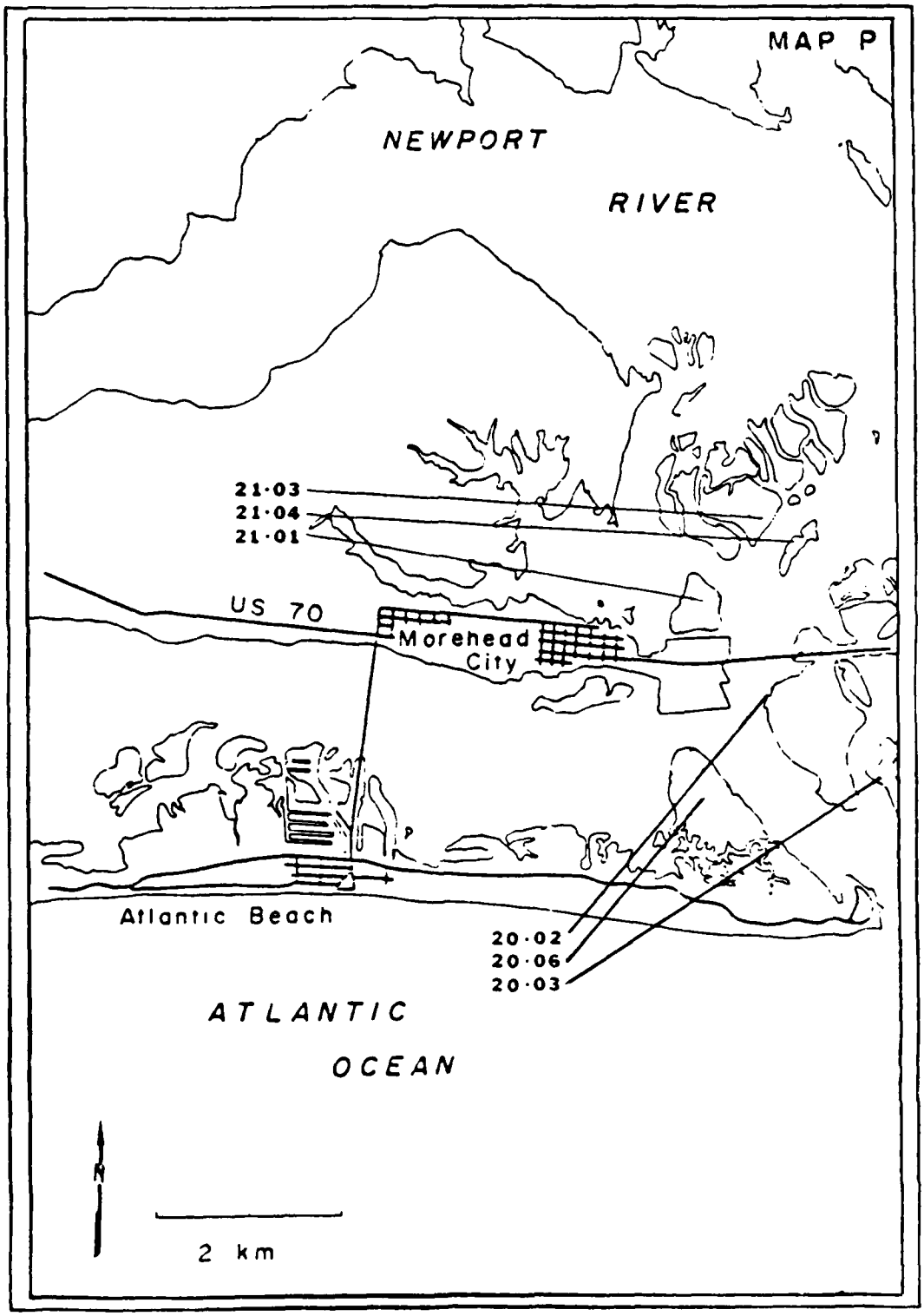

Figure 18. Map P, Morehead City and vicinity

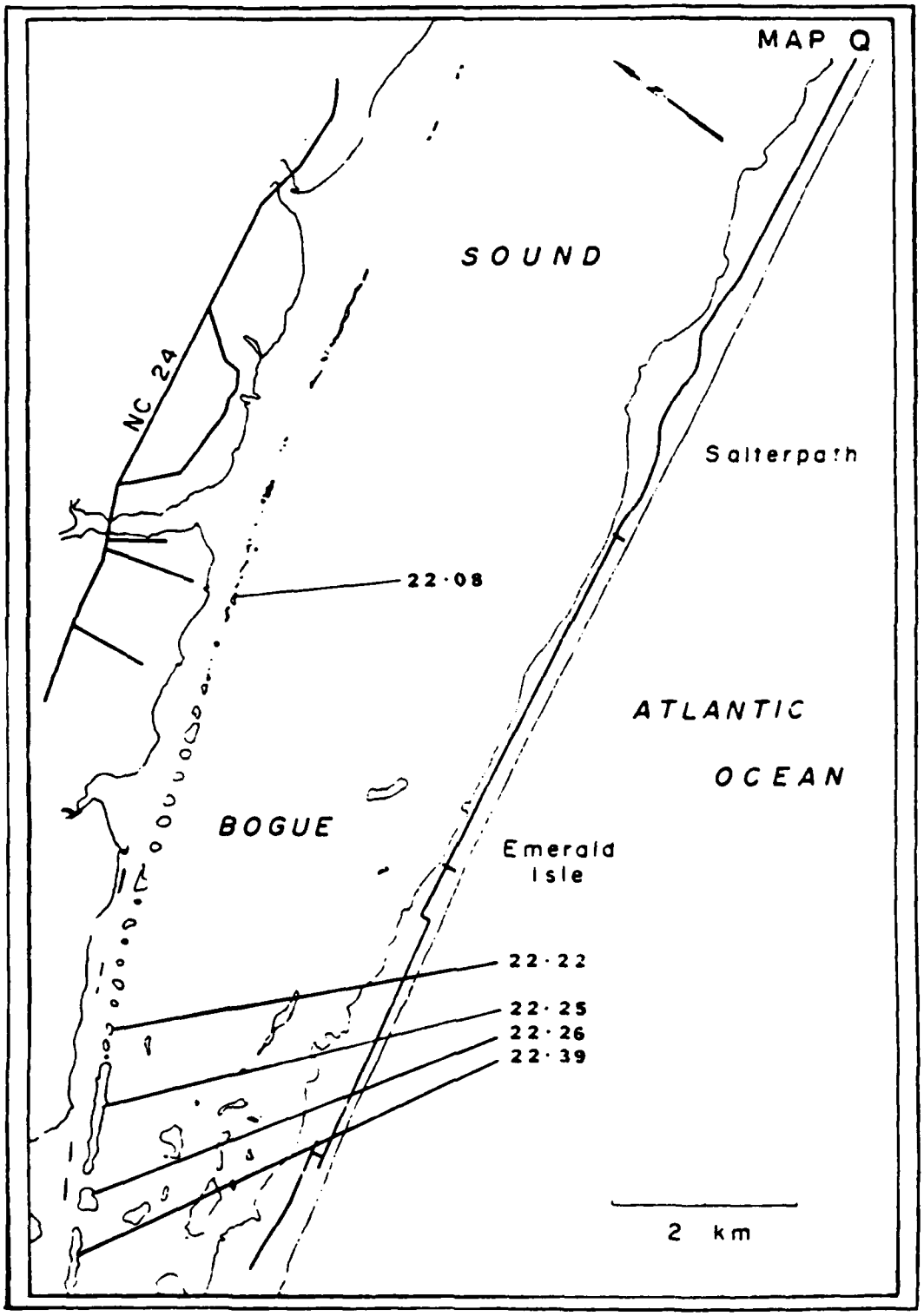

Figure 19. Map Q, Bogue Sound and vicinity

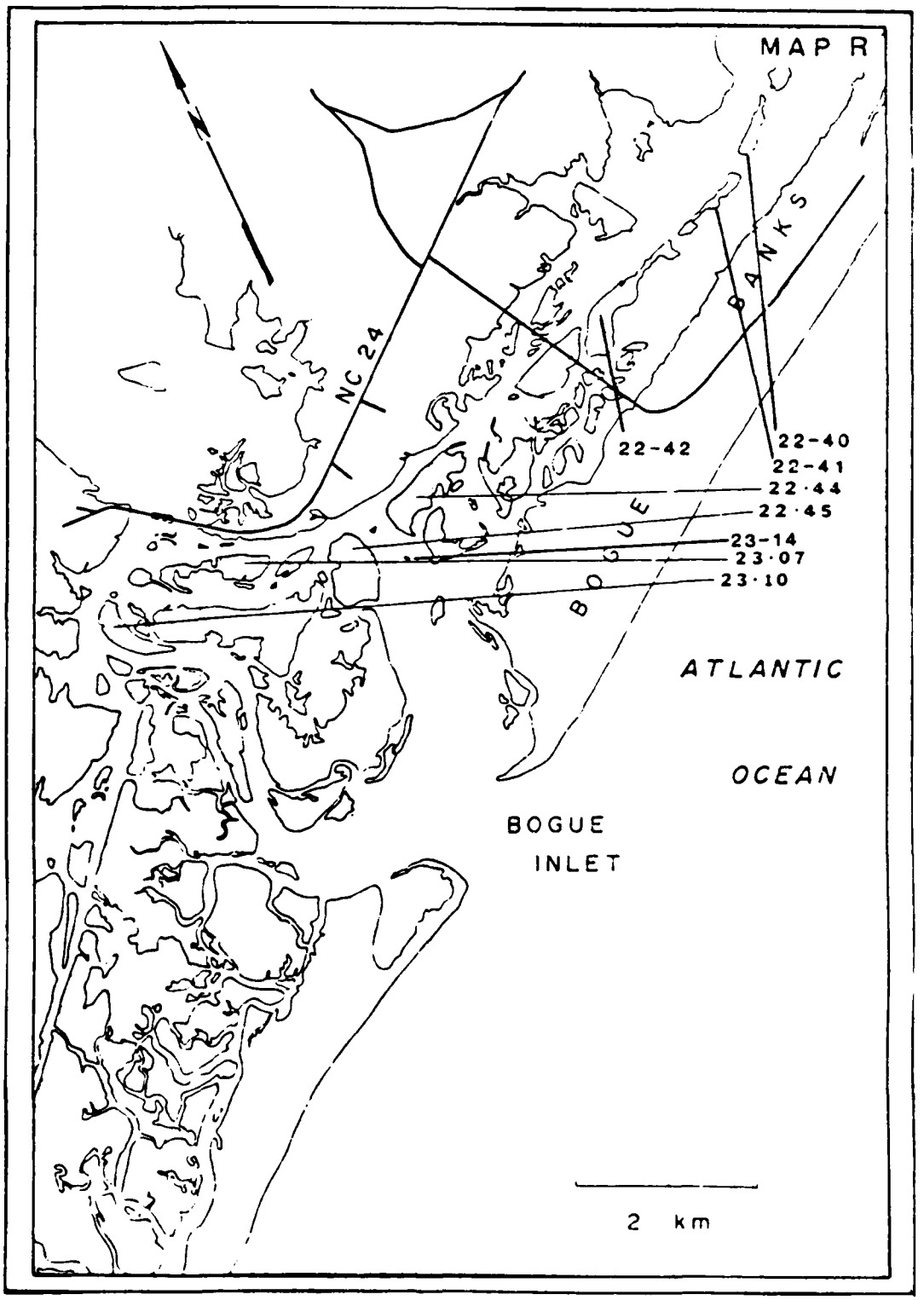

Figure 20. Map R, Bogue Inlet and vicinity

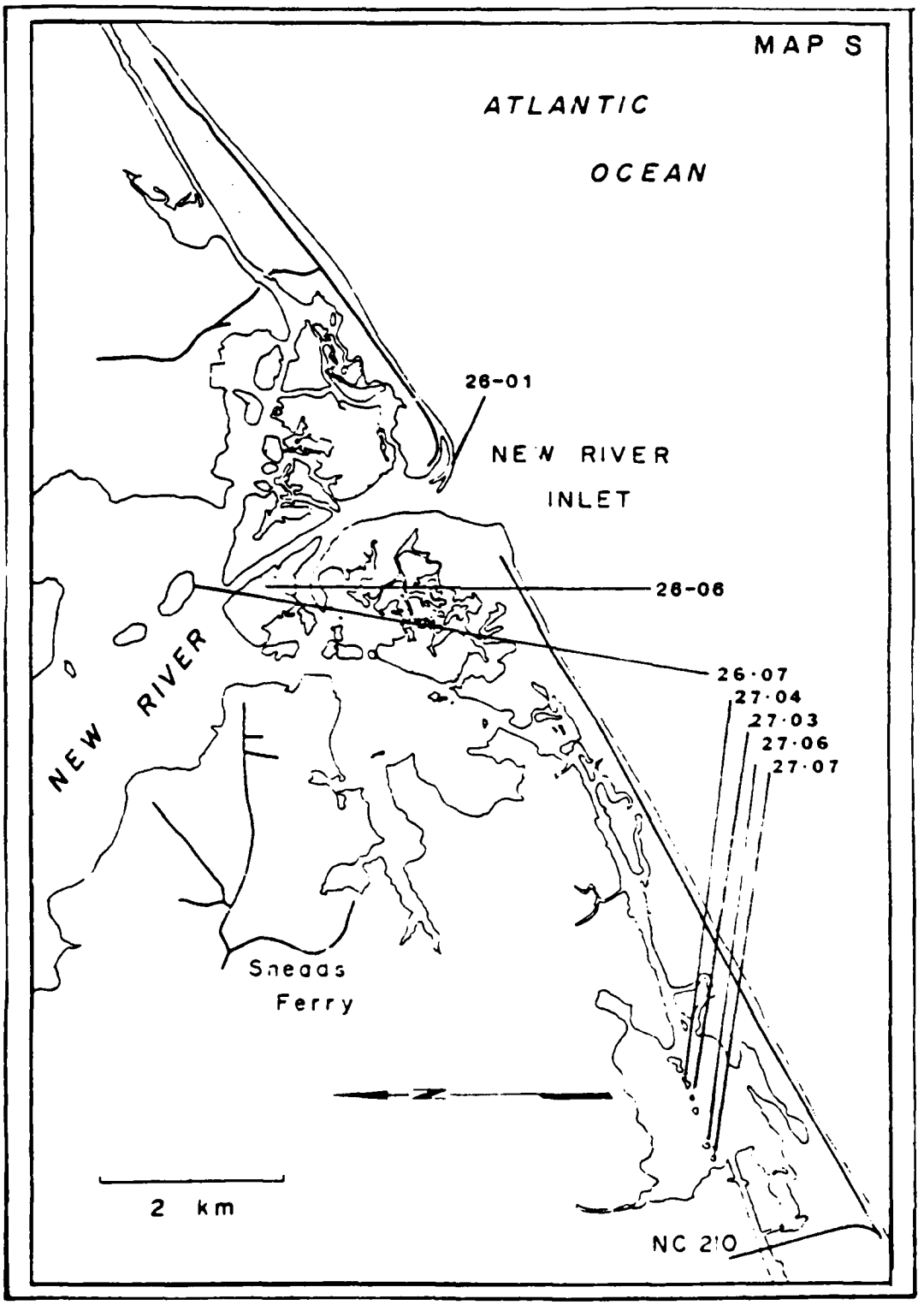

Figure 21. Map S, New River Inlet and vicinity

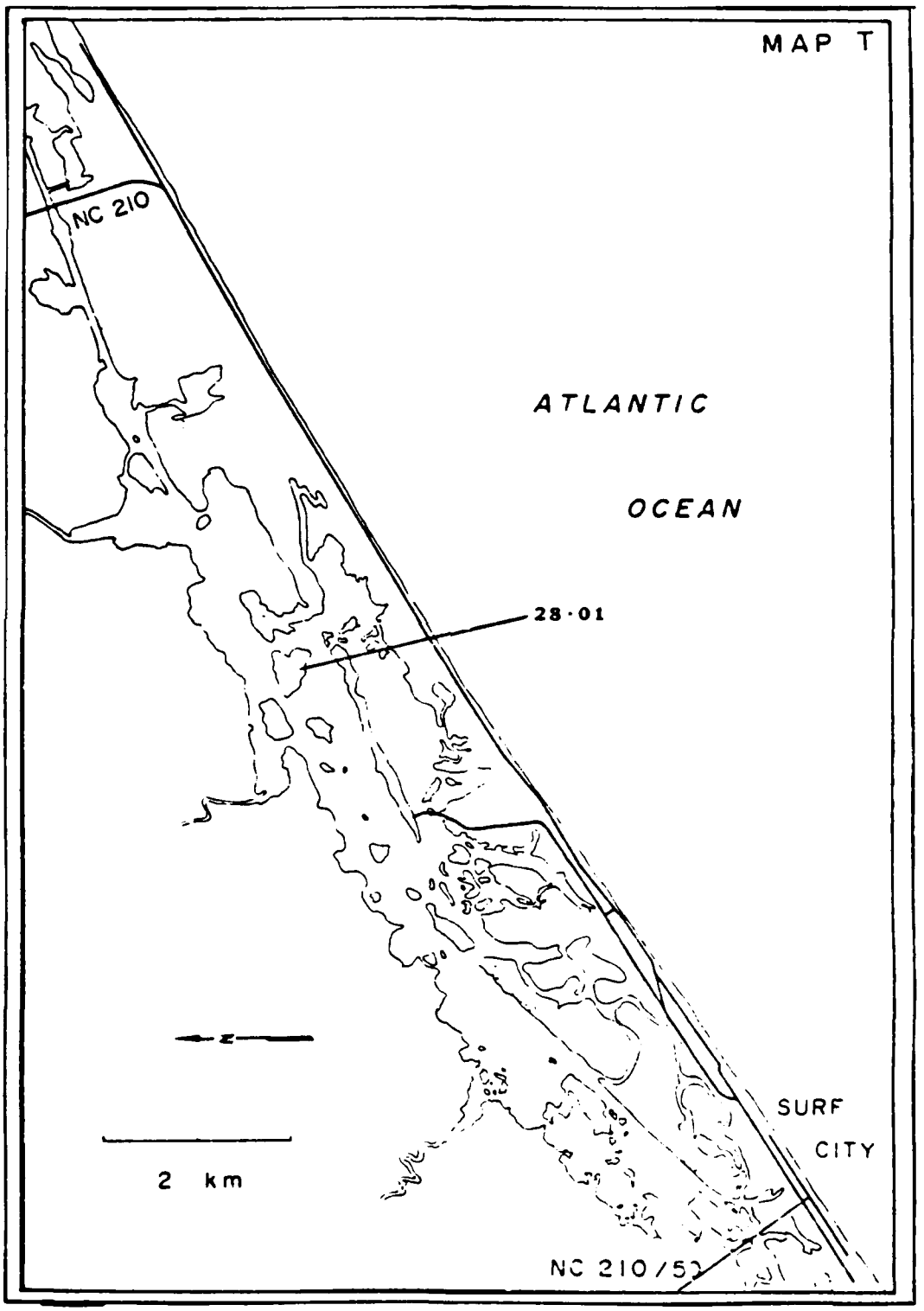

Figure 22. Map T, Surf City and vicinity

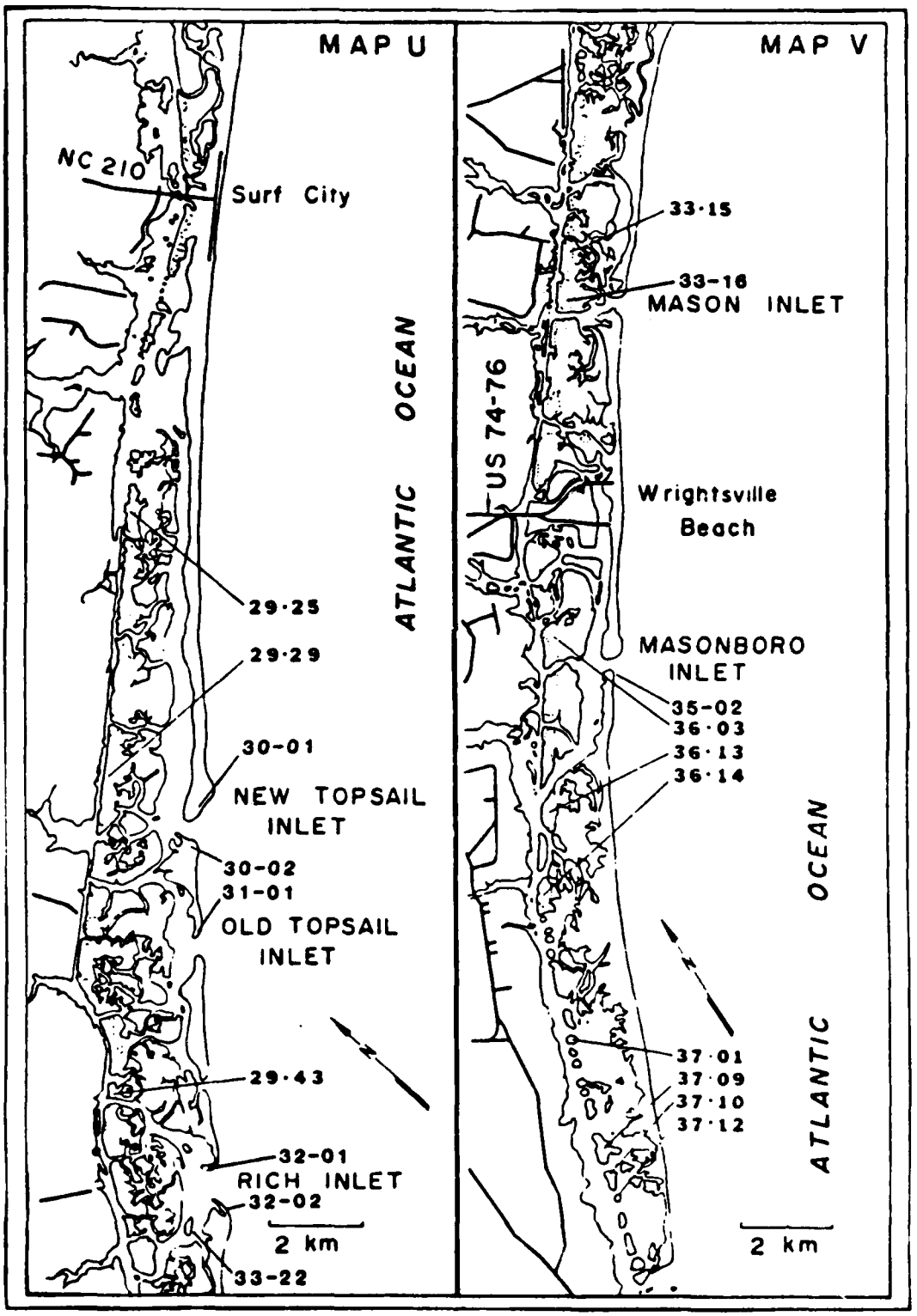

Figure 23. Maps U and V, Surf City to Masonboro Island

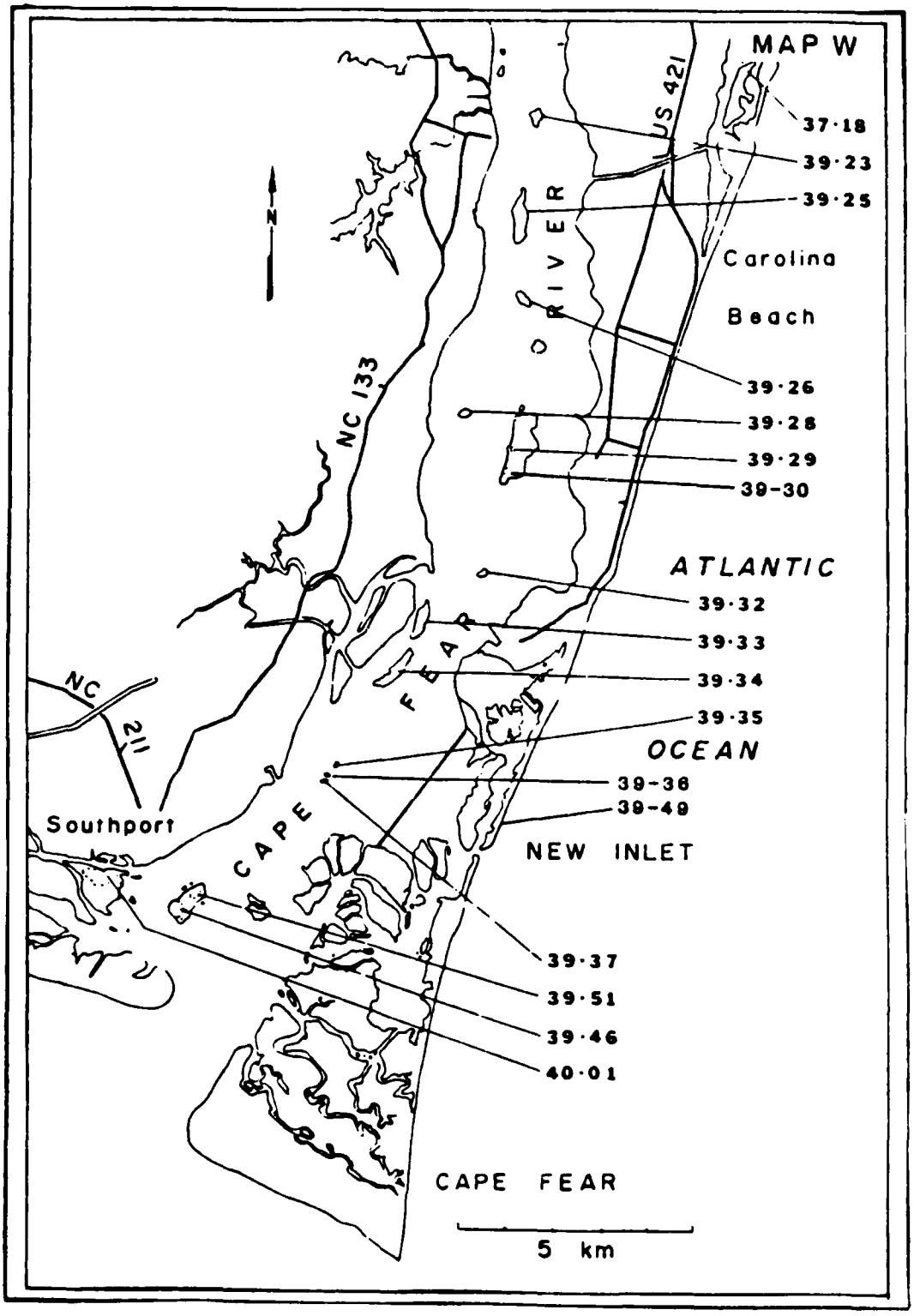

Figure 24. Map W, Lower Cape Fear River and vicinity

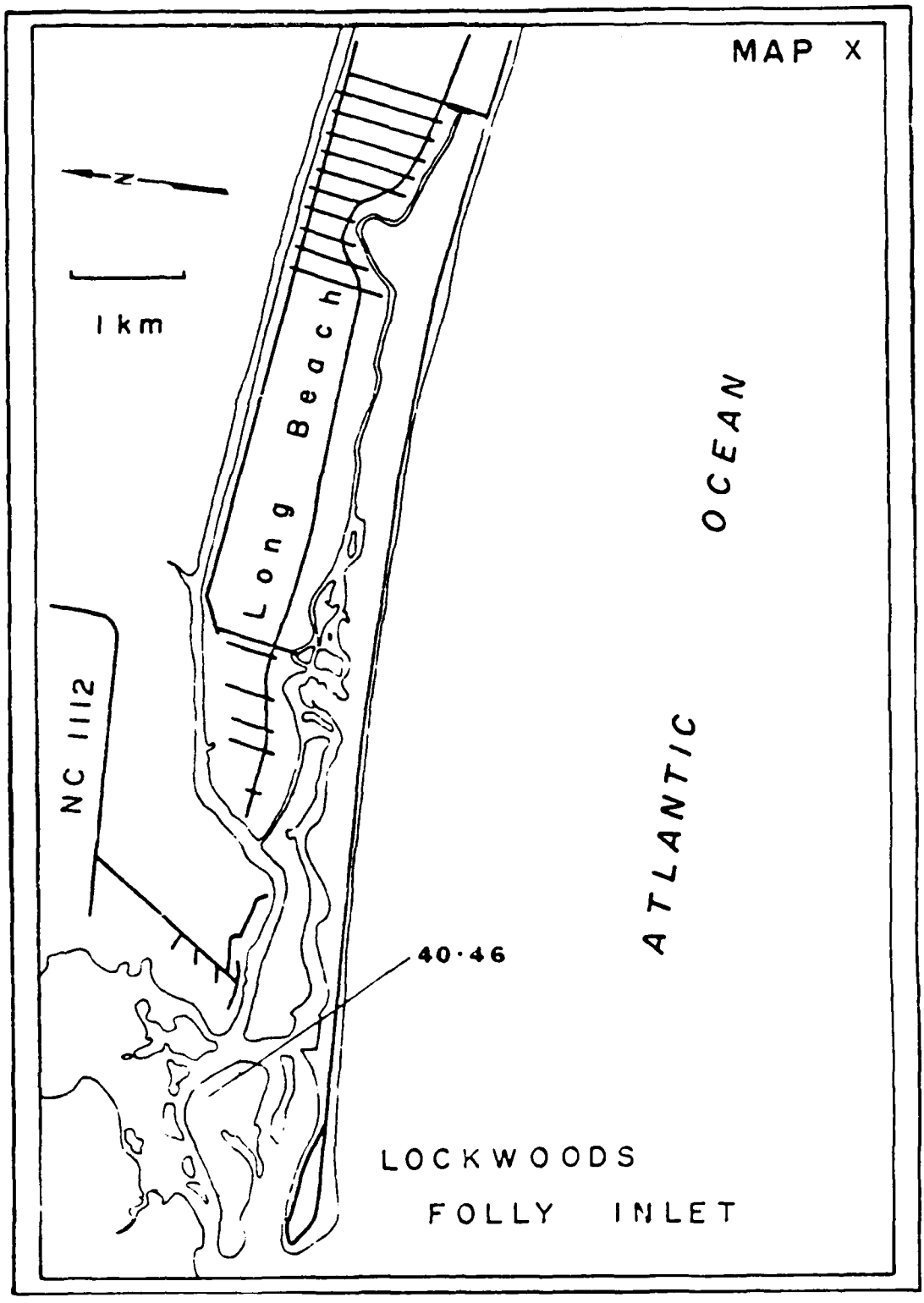

Figure 25. Map X, Long Beach and vicinity

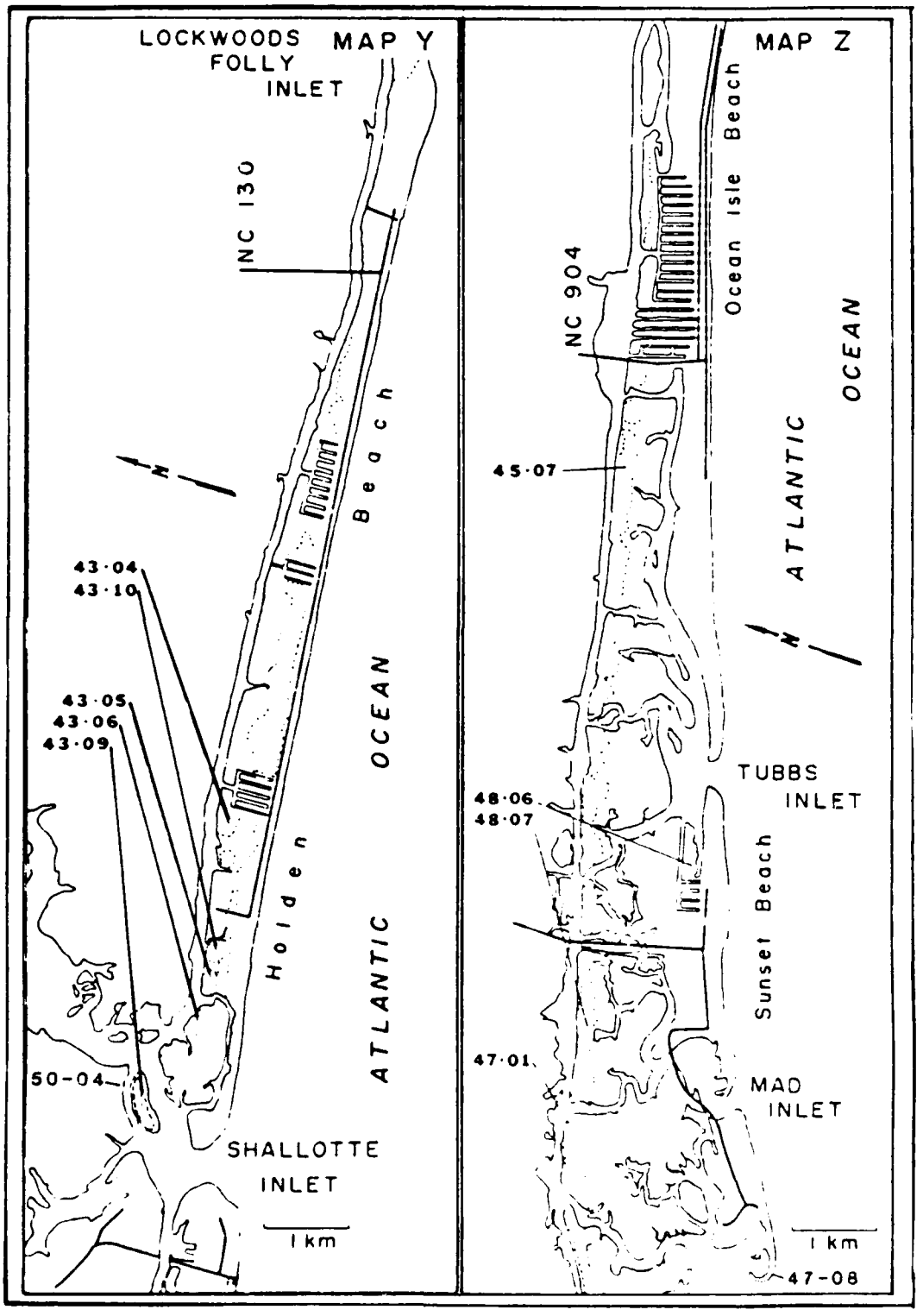

Figure 26. Maps Y and Z, Lockwoods Folly Inlet to South Carolina

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